2

Speculum Nauticum.

A Looking-Glaſs FOR SEA-MEN.

Wherein they may behold, how by a ſmall Inſtrument, called the PLAIN SCALE, all Nautical Queſtions, and Aſtronomical Propoſitions, are very eaſily and demonſtratively performed.

Firſt ſet forth by JOHN ASPLEY, Student in Phyſick, and Practitioner of the Mathematicks in LONDON.

THE EIGHTH EDITION.

Whereunto are added many new Propoſitions in Navigation and Aſtronomy; and alſo a third Book, ſhewing a new way of Dialling. With an Appendix containing the Uſe of all Inſtuments that are uſed at Sea.

By *H. P.* and *W. L.*

Naut. p. 61.

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TO THE

WORSHIPFUL,

THE

MASTER, WARDENS, & ASSISTANTS

OF THE

TRINITY HOUSE;

JOHN ASPLEY,

IN

TESTIMONY OF THE HONOUR

HE BEARS TO THE

GOVERNORS & PRACTICERS

OF THE ART OF

NAVIGATION,

DEDICATES THESE HIS

FIRST LABOURS.

The Stationer to the Reader.

THis little Book having been well accepted of among Sea-men, being the first fruits of Mr. Aspley's *Mathematical Studies, passed six Impressions without any alteration; and so I doubt not might have done still: But because since that time there have been several Books put out of this nature, I have procured this to be revised, and several Alterations and Additions to be made therein: So that here you have both the old, and a new Book intermingled all in one, with a third part added thereto, concerning Dialling, by a way not formerly published by any. All which I doubt not you will kindly accept of, and receive much delight and profit thereby.*

Yours

B. H.

Speculum

Speculum Nauticum,

OR,

THE SEA-MANS GLASS.

The First Book.

CHAP. I.

The Explanation of certain Terms of Geometry.

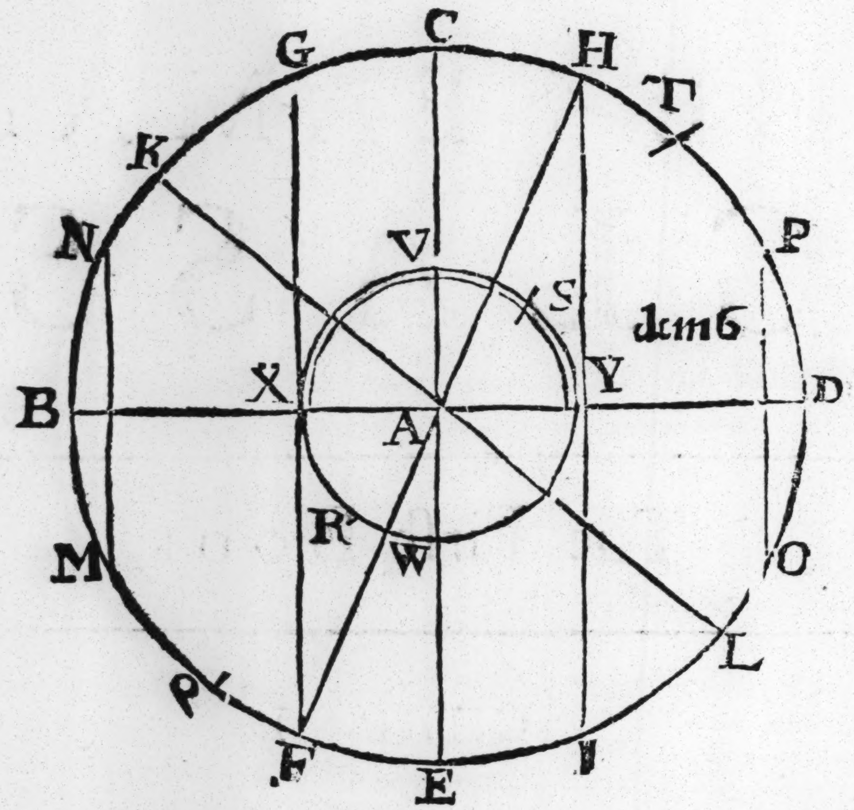
BEing intended in this Treatiſe of the plain Scale, to declare the manner of projection of the Sphere, *in plano*, I have thought fitting, firſt to ſhew unto you ſome terms of Geometry, which are neceſſary for the unlearned to know, (for whoſe ſake chiefly I write this Treatiſe) before they enter into the definition of the Sphere.

Firſt therefore I intend to relate unto you, what a Point or Prick is,

and afterward a Line both right and crooked, and such sorts thereof as are appertinent unto the operations and use of this Scale.

Punctum, or a Point, is the beginning of things; or a Prick supposed indivisible, void of length, breadth, and depth: as in the Figure following is noted by the point or prick A.

Linea, or a Line, is a supposed length, or a thing extended in it self in length, not having breadth nor thickness, as is set forth unto you by the LineB A D.



Parallela, or a Parallel Line, is a Line drawn by the side of another Line, in such sort that they may be equidistant in all places. And of such parallels, two only belong unto this work of the plain Scale, that is to say, the right lined Parallel, and the circular Parallel.

Right lined Parallels are two right lines equidistant one from another, which being drawn forth infinitely, would never touch or meet one another, as you may see in the Figure, where the line H I is parallel unto the line C E, and the line G F is parallel unto them both.

A

A circular Parallel is a circle drawn either within or without another circle upon the ſame center, as you may ſee plainly by the two circles B C D E, and X V Y W. Theſe circles are both drawn upon the center A, and therefore are parallel the one unto the other. There is another kind of Parallel alſo, which is called a Serpentine Parallel, but becauſe it is not belonging unto the uſe of this Scale, I will omit it, and ſo proceed unto the reſt.

Perpendiculum, or a Perpendicular, is a line raiſed from, or let fall upon another line, making equal Angles on both ſides, as you may ſee declared in the Figure, wherein the line A C is perpendicular unto the line B A D, making equal angles in the point A.

Diameter circuli, or the Diameter of a Circle, is a right line drawn thorow the center of any circle, in ſuch ſort that it may divide the circle into two equal parts, as you may ſee the line B A D is the Diameter of the circle B C D E, becauſe it paſſeth thorow the center A, and the two ends thereof do divdie the circle into two equal parts in the two extreams B and D. making the ſemicircle B C D equal unto the ſemicircle D E B.

Semidiameter circuli, or the Semidiameter of a circle, is half of the Diameter, and is contained betwixt the center, and the one ſide of the circle, as the line A D is the Semidiameter of the circle B C D E. This Semidiameter contains 60 degrees of the line of Chords; which we ſometimes call the Radius.

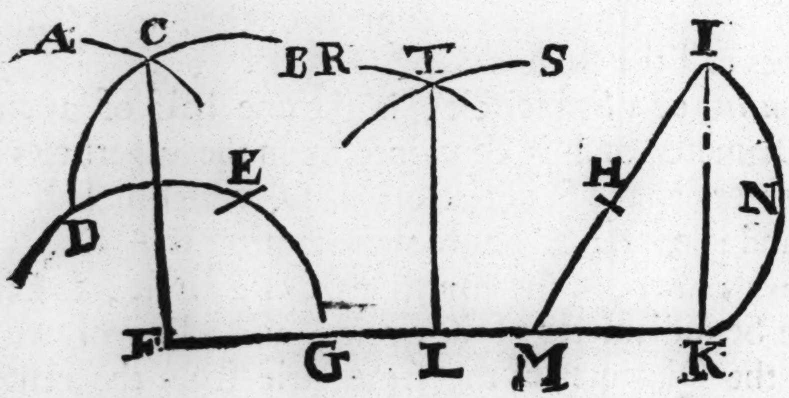
Semicirculus, or a Semicircle, is the one half of a circle drawn upon his Diameter and is contained upon the Superficies or Surface of the Diameter, as the Semicircle B C D, which is half of the circle B C D E, and is contained above the Diameter B A D.

Quadrans circuli, is the fourth part of a circle, and is contained betwixt the Semidiameter of the circle, and a line drawn perpendicular unto the Diameter of the ſame cirle from the center thereof, dividing the Semicircle into two equal parts, of the which parts the one is the Quadrant, or forth part of the ſame circle. As for example, the Diameter of the circle B C D E is the line B A D, dividing the circle into two equal parts: then from the center A raiſe the perpendicular A C, dividing the Semicircle likewiſe into two equal parts; ſo is A B C, or A C D, the Quadrant of the circle B C D E, which was deſired.

CHAP. II.

The manner how to raise a Perpendicular from the middle of a line given.

DRaw first a ground line whereupon you would have a Perpendicular raised, then open your Compasses unto any distance (so it exceed not the end of your line) placing one foot of the said Compasses in the point from whence the Perpendicular is to be raised, and with the other foot make a mark in the line on both sides, then removing your Compasses unto any other distance that is greater, set one foot thereof in one of the marks, and with the other foot make an arch over the middle point; then with the same distance of your Compasses set one foot in the other mark upon the line, and with the other foot make another arch of a Circle over the middle point, so that it may cross the first arch; and from the meeting of these two arches, draw a right line unto the middle point, from which the Perpendicular was to be raised, which line shall be the Perpendicular desired.



Example. Suppose your base or ground line whereupon a Perpendicular is to be raised, be the line F L K, and from L the Perpendicular is to be raised, set one foot of your Compasses in the point L, and with the other make the marks G and M on both sides of the point L; then opening yonr Compasses wider, set one foot in the point M, and with the other draw the arch S over the point L, then

then with the ſame diſtance of your Compaſſes, ſet one foot in G, and with the other make the arch R, croſſing the arch S in the point T, then from T draw the line T L, which line is perpendicular unto the line F L K from the point L, which is the Perpendicular deſired.

CHAP. III.

To let a Perpendicular fall from any Point aſſigned, unto the middle of a line.

LEt the line whereupon you would have a Perpendicular let fall, be the line L F K, and the point aſſigned to be the point T, from whence you would have a perpendicular let fall upon the line F L K; firſt ſet one foot of your Compaſſes in T, and open your Compaſſes unto any diſtance, ſo that it be more than the diſtance T L, which here we ſuppoſe to be the diſtance T M; then make in the line F L K, the marks G and M, then with your Compaſſes take the one half of G M, which is the point L, then from L draw a line unto the point T, ſo the line T L ſhall be the Perpendicular which was deſired to be let fall from the aſſigned point T, unto the middle of the line F L K.

CHAP. IV.

To raiſe a Perpendicular upon the end of a Line.

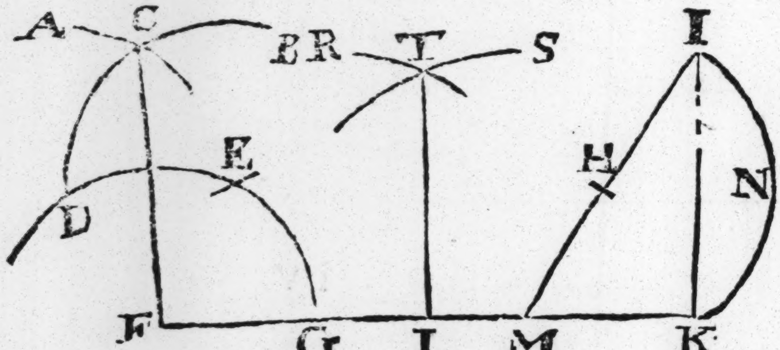
SUppoſe the line whereupon you would have a Perpendicular raiſed, be the line F L K, and from the point of F a Perpendicular is to be raiſed: firſt open you Compaſſes unto any diſtance; which here we put to be the diſtance F G and ſet one foot of your Compaſſes in the point F, and with the other draw the arch D E G, then ſet one foot of your Compaſſes in the point G, and with the other draw the arch E; then placing one point of your Compaſſes in E, with the other draw the arch D B; then place your Compaſſes

Compasses in D, and with the same distance draw the Arch A, cutting the Arch D B in C, then draw a line from C unto the end of the line F L K, unto the assigned point F, so shall the line C F be a perpendicular raised from the end of the line F L K, and from the assigned point F.

CHAP. V.

To let a Perpendicular fall from any point assigned, unto the end of a Line.

LEt the line F L K be the Base or ground line, and from the point I a perpendicular is to be let fall upon the end of the line at K, first from the assigned point I, draw a line unto any part of the Base, which shall be the line I H M, then find the middle of the line I M, which is at H; place therefore one foot of your Compasses



in the point H, and extend the other unto I, with which distance draw the Arch I N K upon the center H, cutting the Base or ground line in the point K, then draw the line K I, which line shall be the Perpendicular desired.

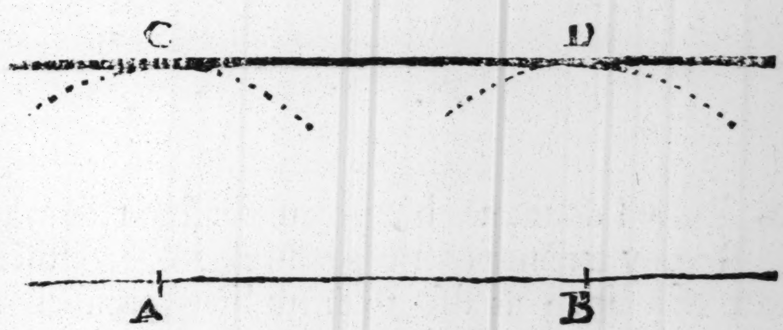
CHAP.

CHAP. VI.

A right line being given, how to draw another parallel thereunto at any distance required.

LEt the line given be A B, unto which it is required to draw another right line C D which shall be parallel to the former line A B, and at the distance A C.

First open your Compasses to the distance A C, then set one foot in the point A, with the other describe the Arch C; Again, place one foot in B, and with the other decribe the Arch C; Then draw the line C D so that it may only touch the two Arches C and D, so shall the line C D so drawn, be parallel to A B, and at the distance required.



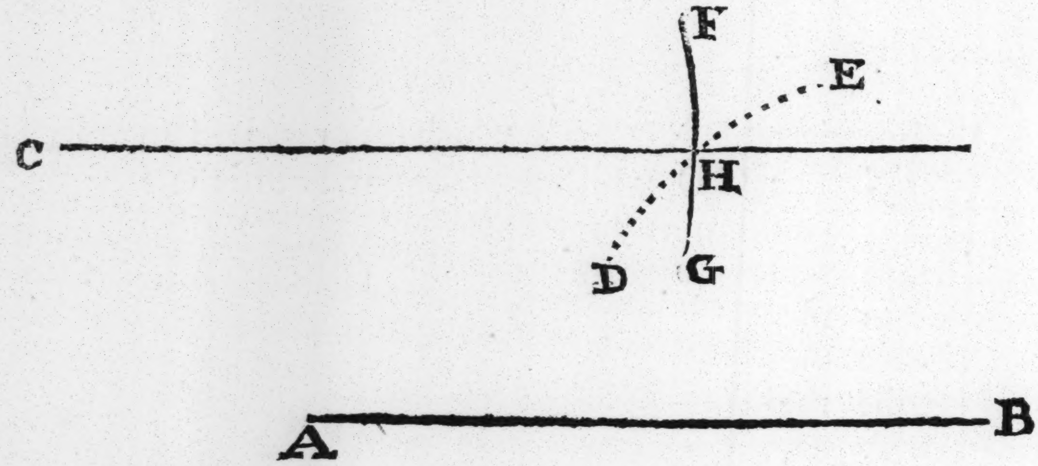
CHAP. VII.

A right line being given, how to draw another parallel thereunto, which shall also pass through a point assigned.

LEt A B be a line given, and the point assigned be C: and let it be required to draw another line parallel thereunto, which shall pass through the given point C.

First, Take with your Compasses the distance from A to C, and placing one foot thereof in B, with the other describe the Arch D E, then take in your Compasses the whole line A B, and placing one foot

foot in the given point C, with the other foot describe the arch F G, crossing the former arch D E in the point H. Lastly, if you draw the line C H, it shall be parallel to A B.



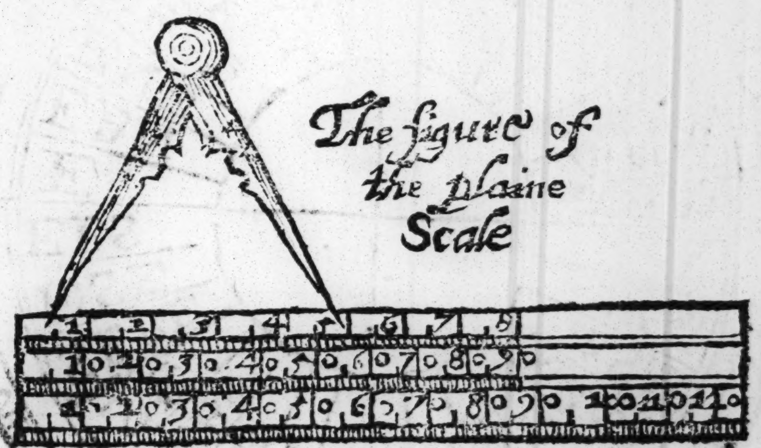
NOw I doubt not but you understand the way to let fall or to raise any manner of Perpendicular line, either from, or upon any part of a line; as also to draw lines parallel one to another at any distance required: therefore now I intend to proceed unto the main point here aimed at, which is, to declare and make known unto you the several operations performed by the plain Scale, which though it be in use with very few, yet it is most necessary for Sea-men, because all questions in Navigation are thereby easily and plainly wrought. And also all questions in Astronomy (belonging unto the expert and industrious Sea-men) may both speedily and easily be wrought by the same Scale: in regard whereof I have declared in this little Book that knowledg (which God hath been pleased to bestow upon me) concerning the necessary use and practise thereof; hoping that you will as kindly accept it, as it is freely offered unto your courteous considerations.

CHAP.

CHAP. VIII.

Of the Description of the Scale.

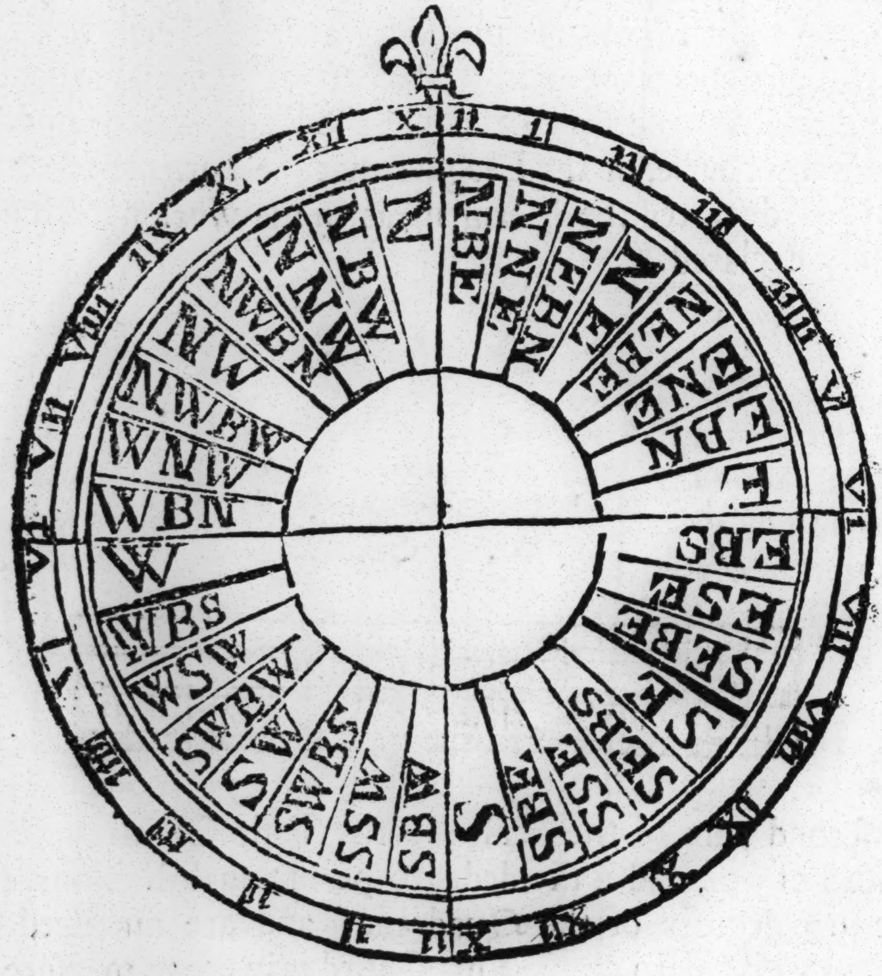
THis Scale usually is divided into three parts, the first whereof is a Scale of equal parts, divided into Miles or Leagues, from 1 unto 100. and upwards at your pleasure, and numbred with 10,20,30, 40, and so forth unto the end. All these divisions are equal one unto another, and is in use for to measure the Leagues that any Ship hath run, upon any course, or the Leagues that she hath raised or depressed the Pole, or departed the Meridian, as in the work hereafter shall be more fully declared.



The second part of the Scale, is the single Chord of a Circle, or the Chord of 90, and is divided into 90 unequal divisions, representing the 90 degrees of the Quadrant: and are numbred with 10, 20, 30, 40, &c. unto 90. This Chord is in use to measure any part or arch of a Circle, not surmounting 90 degrees: The number of these degrees from 1 unto 60 is called the Radius of the Scale, upon which distance all circles are to be drawn, whereupon 60 of these Degrees are the Semidiameter of any Circle that is drawn upon that Radius.

The third part of the Scale is divided into eight parts, representing the Points or Rumbs of the Mariners Compass; which in all

are 32 points: but upon the Scale there are only 8 reckoned, which is but one Quadrant or quarter of them, being to be reckoned from the Meridian of North and South both ways, as you see more plainly by this Figure, representing the order of the points of the Compass.



It is usual also to have another line placed upon your Scale, to shew you how many leagues make a degree of longitude in every latitude; Concerning which you shall have directions in the 14 Chapter following.

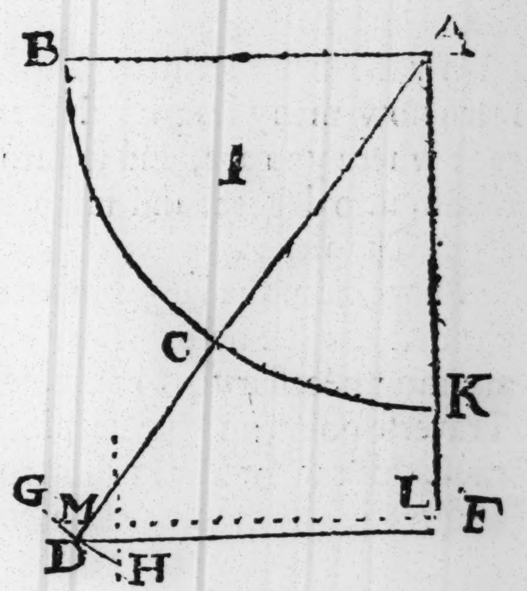
CHAP.

CHAP. IX.

Knowing the course any Ship hath made, and the leagues she hath sailed: to find how much she hath raised or depressed the Pole, and likewise how much she is departed from her first Meridian.

The course is South-west and by South the Leagues sailed are 100, the difference of the Latitude, and the distance of the Meridian is required.

IN the first demonstration, first draw the line A B, and from the center A, let fall, the perpendicular A F, which represents the Meridian; then opening your Compasses unto the Radius of your Scale, set one foot thereof in the Center A, and with the other draw the arch KCB: then in regard your Course is South-west and by South, that is 3 points from the South, take three of the eight points of the compass with your Compasses out of your Scale and place them from K to C; then draw the line A C D, which represents the Rumb or point of the Compass you have sailed upon; then cut off your Scale of leagues, take with your Compasses the number of leagues you have sailed upon this course, which is 100 leagues, and place them upon the Rumb line A C D, from A to D, crossing the line A C D at the end thereof with the arch G D H: then from the point D, draw the line D F parallel to the line A B, so it will cut the Meridian line A K F in the point F.



Now you must heedfully observe this point D, for this represents the place where your Ship is, and doth shew both the difference of the latitude of the place you are in, and also your distance or departure from your first Meridian.

First for the latitude, You see the line D F, being parallel to the line

line A B, cuts the Meridian line A F in the point F: So that if you take the distance F a with your Compasses, and apply it to the scale of equal leagues, you shall find it is just 83 leagues, which counting 20 leagues to a degree, makes 4 degrees 9 min. and so much you have altered your latitude by the said course; which degrees and minutes being added to, or substracted from the latitude of the place you came from, according as your course requires, shews you always the true latitude you are in.

Likewise from this point D, take with your Compasses the distance D F, and you shall find it by your scale of equal leagues to be 56 leagues; and so much you are departed from your first Meridian to the Westward: which when you are near the Equinoctial, where the degrees of longitude are equal to the degrees of latitude, would shew the longitude, by taking 20 leagues for one degree, *&c.* so it would be two degrees and 48 min. for your difference of longitude from your first Meridian A F. But in other places you must first learn how many leagues make a degree of longitude about that latitude where you are, and so turn your leagues of distance from the Meridian, into degrees and minutes of longitude; of which more hereafter, Chap. 14.

I have been the larger in these two Propositions, because they are the first, for the better understanding of all the rest; and because they are most necessary, for thereupon depends the knowledg of the true Traverse point, and the keeping of your dead reckoning. Now because this cannot always be kept exactly, it is to be corrected by the observation of the latitude, according to this following proposition.

CHAP.

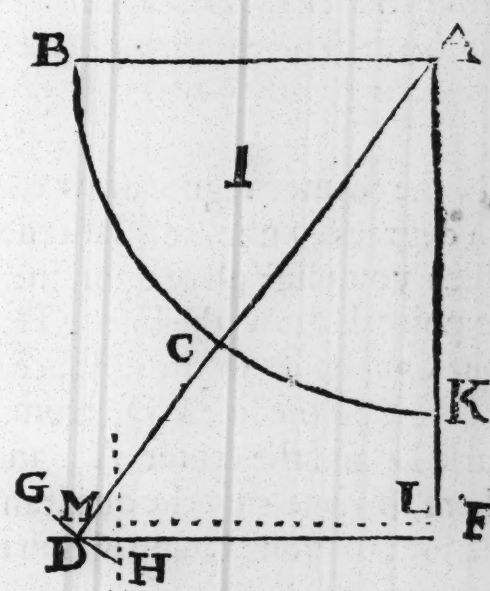
CHAP. X.

Knowing the difference of latitude of two places, and the Rumb you have sailed upon, to find the leagues you have sailed, and the difference of Meridians.

The Pole depressed four degrees, and the Rumb South-west by South, or the third from the Meridian, to find your true Traverse point, viz. *how far you have sailed, and how much you are departed from your first Meridian.*

In the first Figure.

DRaw the lines as in the former Chapter, so that A K F may represent the Meridian line, and A C D may represent the third Rumb from the Meridian; then because you have altered your latitude 4 degrees, which make 80 leagues, take 80 leagues with your Compasses out of your scale, and set them upon the Meridian line A F, from A to L: Then keeping the same distance of your Compasses, draw the line L M parallel to A B, (or else you may erect L M perpendicular to the line AF, in the point L) and mark where the said LM crosseth the Rumb line ACD, which is in the point M. This point M is the true Traverse point, the leagues sailed are shewed by the line A M, which being measured in the scale, will be found to be *96* leagues and an half, and the departure from the Meridian is L M, which is 54 leagues



Now by this Proposition (as I said) you may correct your dead reckoning; for suppose by the former proposition you reckon you had sailed 100 leagues upon the third Rumb, then as you see there, you should have been at the point D, and have altered your latitude 83 leagues

83 leagues, and departed from your Meridian 56 leagues ; but now suppose that by a good observation of the latitude, you find that you have altered the latitude only 80 leagues from A to L, by drawing the line L M, which crosseth the Rumb or Ships way in M, you may conclude your true traverse point to be at M, so that you have sailed only from A to M, which is 96 leagues $\frac{1}{7}$, and departed from your Meridian 54 leagues. So that as you are short of the latitude you reckoned for, 3 leag. or 9 min. you are also short of your way you reckoned 3 leag. $\frac{1}{3}$, and 2 leagues less in you departure from the Meridian. And this you must account for your true reckoning, being thus corrected.

CHAP. XI.

By the difference of the latitudes of two places and the distance between their Meridians, to find the Rumb by which you must sail from the one place to the other, and how far it is from one place to the other.

The difference of latitude between the two places is 4 deg. 9 min. and the distance between the two Meridians is 56 leagues, and is required to find the Rumb from the one place to the other.

IN the former Figure draw the Quadrant A K C B, then turn your 4 degrees 9 min. of latitude into leagues, it maketh 83 leagues, which you must place upon the Meridian line from A to F. And from the point F draw the line F D parallel to the line A B. Then open your Compasses to the distance of the Meridians, which is 56 leagues, and set it on the line F D, from F to D. Then lay your Ruler by this mark D and the center A, and draw the line A C D. Then mark where this line cuts the quadrant, which is in the point C, and setting one foot of your Compasses in the point C, open the other to K, and keeping your Compasses at that distance C K, measure it upon your Scale, either in the line of Chords, or in the line of Rumbs, you shall find it to be in the one 33 deg. 45 min. and in the other just the third Rumb from the Meridian. So that the Rumb from A to D is South-west and by South, and the Rumb from D to A is the Rumb opposite thereunto, which is North-east and by North.

Then

Then for the distance between the two places in the Rumb, set one foot of your Compass in the one place at A, and open the other to the other place at D: and the length of the line A D measured in the Scale of leagues, shews the distance between them to be just 100 leagues.

These three (or rather these six) Propositions, (for they are each of them double) are the most useful and necessary in the art of Navigation. By the first of these, knowing the point of the Compass you sail upon, and judging how many leagues you have sailed thereon, you know and are able to give a reasonable account where you are, both in respect of latitude and longitude. By the second, having a fair observation of the latitude at any time, you may more perfectly know where you are; and thereby correct your former account. And by this third you may know how to direct your course from any place to your desired Haven. So that in effect you need no more, but yet for your better instruction by variety of cases and examples, I shall proceed.

CHAP. XII.

The difference of latitude and the leagues sailed being given, to find the distance from the Meridian, and the Rumb you have sailed upon.

Sailing 100 leagues between South and West, untill the Pole be depressed 4 deg. 9 min. the distance from the Meridian is demanded, and what Rumb you have sailed upon?

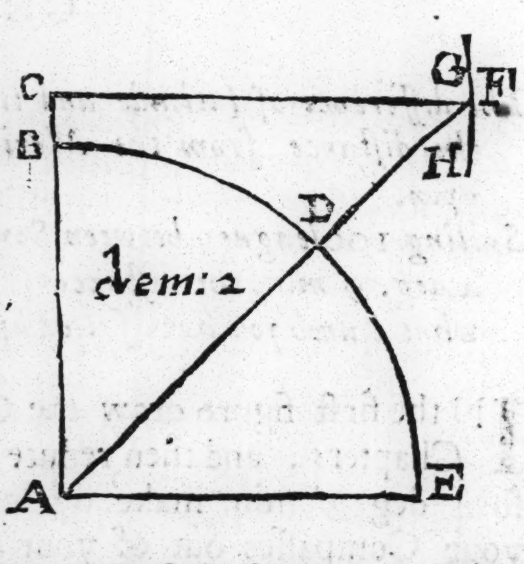
IN the first figure draw the Quadrant A K C B, as in the former Chapters, and then reduce your degrees of latitude into leagues, so 4 deg 9 min. make 83 leagues, which you must take with your Compasses out of your Scale of leagues, and set them off in this Meridian line from A to F. Then from the point F draw the line F D, parallel to the line A B, which you may do with the foresaid distance of your Compasses. Then open your Compasses unto your distance sailed, which is 100 leagues, and setting one foot of your Compasses in the point A, with the other draw the little

arch H G, cutting the line F D in the point D. So the line F D measured in the scale of leagues, shall shew you the distance from the Meridian, which is 56 leagues; if you draw the line A C D, it is the Rumb line upon which you have sailed, and the arch K C measured in the scale of Rumbs, shews it to be the third Rumb from the Meridian, or South-west by South.

CHAP. XIII.

To find the distance of any Island from you, that you may discern at two stations, knowing the point of the Compass, the Island beareth unto each of the stations.

Suppose, being at Sea you discover an Island bearing North-east off you, which place let it be your first station, and then sailing seven leagues full North, you observe the Island to bear full East off you, which let be the second station; the demand is to find the distance of the said Island from both the said stations?



IN the second Figure, or demonstration, let A be the first Station, and upon the Center A draw the Quadrant A B D E; Then in regard you found the Island to bear North-east from you, take four of your eight points of the Compass out of the scale, and place them upon your Quadrant from B to D, then from the Center A by the point D, draw the line A D F, representing the visual line passing between your sight and the Island, being at the first station A. Then seeing when you had sailed 7 leagues North, you observed the Island to bear full East off you, set off the said seven leagues from A to C, (reckoning every 10 leagues of your scale to be but one) and from this point C, which is the second station, draw the line C F parallel

to

to A E, and it will cut the line A D F in the point F: so shall the point F be the place of the Island desired, and the distance A F, is the distance of the Island from the first station, *viz.* 9 leagues 90 parts or almost 10 leagues: Likewise the distance from C to F is the distance of the Island from the second station, which is just 7 leagues. And by this manner of work, you may find the distance of any Island or head land from you, or you may take the distances of as many places as you will or can see at two such stations, and by the crossing of their visual lines, find their position and distances each from other.

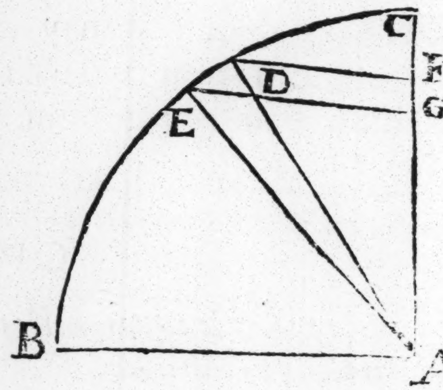
CHAP. XIV.

To find how many leagues, miles, and parts, do make one degree of longitude in every latitude.

Note, *All this while we have been sailing according to the Rules of the plain Chart, which supposeth the degrees of longitude to be equal to the degrees of latitude, in all latitudes, but that is very false and erroneous; it being true only in places near the Equinoctial, where every degree of longitude contains 20 leagues, as the degrees of latitude do; But in places near the Poles it alters very much, so that in the latitude of 60 degrees, 10 leagues make a degree of longitude; and in other latitudes the degrees of longitude alter, as in this little Table, which shews at what degree and minute of latitude any number of leagues make a degree of longitude, by which you may divide a Line upon your Scale for your ready use.*

Leagues in one degree.			Leagues in one degree.		
20	00 d	00 m	10	60 d	00 m
19	18	11	9	63	15
18	25	50	8	66	25
17	31	47	7	69	31
16	36	52	6	72	32
15	41	25	5	75	31
14	45	34	4	78	28
13	49	27	3	81	22
12	53	08	2	84	16
11	56	38	1	87	8

Now to return to the Question, and shew you by demonstration how to find how many leagues, miles, and parts, make a degree of longitude in any degree of latitude?



TAke 60 parts out of your Scale of equal parts, which you must reckon for miles, and count three of them to a league, and therewith draw the Quadrant A B C, then from the point B, set off the degree of the latitude proposed (which for example, let it be 58 deg. 54 min.) from B to D, then from the point D draw the line D F parallel to A B, so shall the length of this line D F, being measured in your Scale of leagues, shew you the number of leagues and miles, which answer to a degree of longitude in the said latitude of 58 deg. 54 min. which you shall find to be 31 miles, or 10 leagues and one mile. So also B E being the arch of 51 deg. 55 min. the line E G shews one degree of longitude to be 37 miles, or 12 leagues and one mile.

The larger you make your Quadrant, the more exactly will the work be, and shew the leagues and miles more exactly, which you may make into a Table, as this following.

A Table shewing how many leagues, miles, and hundred parts of a mile make one degree of longitude in any latitude.

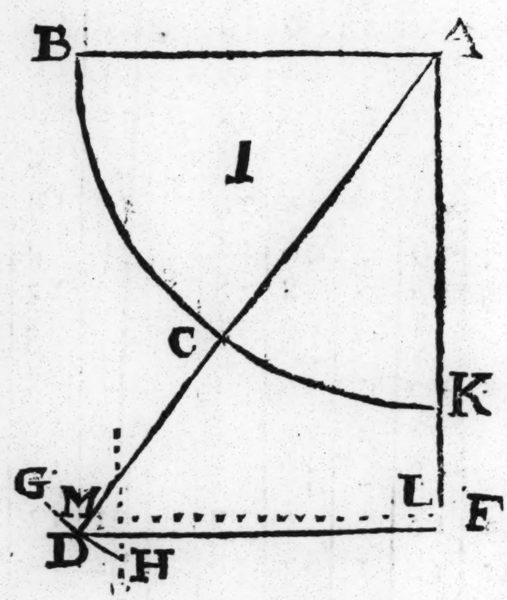
Latitude	Leagues	Miles	Parts	Differ.	Latitude	Leagues	Miles	Parts	Differ.	Latitude	Leagues	Miles	Parts	Differ.
0	20	0	0	—	30	17	0	96	—	60	10	0	0	—
1	19	2	99	1	31	17	0	43	53	61	9	2	9	91
2	19	2	96	3	32	16	2	88	55	62	9	1	17	92
3	19	2	92	4	33	16	2	32	56	63	9	0	24	93
4	19	2	85	7	34	16	1	74	58	64	8	2	30	94
5	19	2	77	8	35	16	1	15	59	65	8	1	36	94
6	19	2	67	10	36	16	0	54	61	66	8	0	40	96
7	19	2	55	12	37	15	2	92	62	67	7	2	44	96
8	19	2	42	13	38	15	2	28	64	68	7	1	47	97
9	19	2	26	16	39	15	1	63	65	69	7	0	50	97
10	19	2	09	17	40	15	0	96	67	70	6	2	52	98
11	19	1	90	19	41	15	0	28	68	71	6	1	53	99
12	19	1	69	21	42	14	2	59	69	72	6	0	54	99
13	19	1	46	23	43	14	1	88	71	74	5	2	54	100
14	19	1	22	24	44	14	1	16	72	73	5	1	54	100
15	19	0	96	26	45	14	0	43	73	75	5	0	53	101
16	19	0	68	28	46	13	2	68	75	76	4	2	52	101
17	19	0	38	30	47	13	1	92	76	77	4	1	50	102
18	19	0	06	32	48	13	1	15	77	78	4	0	48	102
19	18	2	73	33	49	13	0	36	78	79	3	2	45	103
20	18	2	38	35	50	12	2	57	79	80	3	1	42	103
21	18	2	1	37	51	12	1	76	81	81	3	0	38	104
22	18	1	63	38	52	12	0	94	82	82	2	2	35	103
23	18	1	23	40	53	12	0	13	83	83	2	1	31	104
24	18	0	81	42	54	11	2	27	84	84	2	0	27	104
25	18	0	38	43	55	11	1	41	86	85	1	2	23	104
26	17	2	93	45	56	11	0	55	86	86	1	1	18	104
27	17	2	46	47	57	10	2	68	87	87	1	0	14	104
28	17	1	98	48	58	10	1	80	88	88	0	2	09	104
29	17	1	84	50	59	10	0	90	90	89	0	1	05	104
30	17	0	96	2	60	10	0	0	90	90	0	0	0	105

CHAP. XV.

The difference of latitude, and the Rumb or distance sailed being known, to find the distance of the Meridians, and thereby to find the degrees and minutes of the difference of longitude in any latitude.

Sailing from the North Parallel of 56 *degrees and* 5 *min. latitude,* 100 *leagues upon the third Rumb from the Meridian,* viz. *South-west and by South, until I find the Pole is depressed* 4 *degrees* 9 *minutes, and the Meridional distance* 56 *leagues; the longitude is desired thereby?*

In the first Figure



DRaw the quadrant as is shewed before, then reduce your 4 degrees 9 min. of latitude into leagues, it makes 83 leagues, which set off upon the Meridian Line from A to F. Then upon the Rumb line A D C set off the distance sailed from A to D, and after, by these two points, draw the line F D; so shall D represent the place of the Ship, and as A F is the difference of latitude, so F D is the difference of Meridians, which measured in your Scale of leagues is 56 leagues.

Now to reduce this 56 leagues into degrees of longitude, you must consider from what latitude you have sailed, and to what latitude you are come, *viz.* from latitude 56 d. 5 m. to 4 deg. 9 min. less, which is 51 deg. 56 min. and take the middle latitude or somewhat more between the two places, which in this example falls out to be 51 d. 1 m. Then by the Table in the former Chapter, find out how many leagues and miles in the said middle latitude make one degree

degree of longitude, and you shall find in that Table, that in the latitude of 54 d. there is but 11 leagues, and 2 miles, and 27 parts in one degree of longitude, Therefore open your Compasses upon your Scale of leagues to this 11 leagues, 2 miles, 27 parts, and keeping your Compasses at that distance, set one foot of them at 56 leagues in your Scale of leagues, or in the line D F in the Figure (or upon the like line in your Chart at any time) either at F or D, and measure how many times you find that distance either to the end of your Scale coming backward, or in the line D F, for so many degrees is the difference of longitude; and if any odd part remain, you may proportion it by your eye, judging it to be a quarter, a third, an half, or any part more or less of a degree, which you may either reckon by parts, or 15, 20, 30, &c. minutes.

Thus this line D F being 56 leagues, opening your Compasses to 11 leagues 2 miles 27 parts, you will find this distance in it, 4 times and 3 quarters; so that the difference of longitude is 4 deg. 45 min.

Or you may reduce it into miles and work by the rule of proportion, so you shall find

As 11 leagues 2 miles 27 parts, that is 35 miles 27 parts,	35,27
To one degree of longitude in the latitude of 54 d.	01,00
So is 56 leagues, or 168 miles,	168,00
To 4 degrees 76 parts,	04,76

But if your Scale be large, the other way with your Compasses will give you the degrees and parts of longitude as exactly as you need, for most uses.

Also if the latitude fall not out in equal parts, you may find out for your odd minutes by proportion; for which purpose I have set the differences between each degree in the Table.

So that as one hundred parts, or 60 minutes, being one degree to the difference in the Table between the two next degrees;

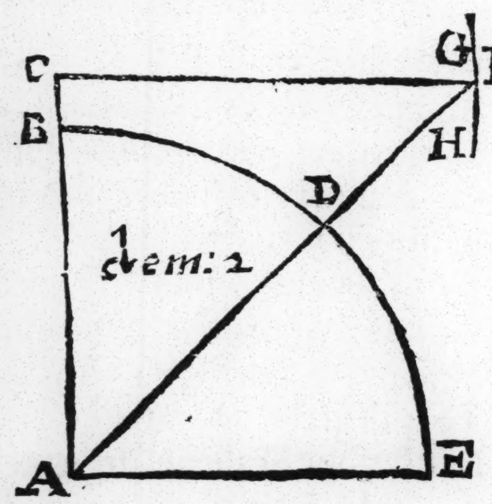
So the odd hundred parts or minutes of latitude, to the parts and minutes proportional to be allowed.

CHAP.

CHAP. XVI.

Sailing from the South latitude of 60 degrees 51 min. and from longitude 25 degrees 24 min. 99 leagues, upon a South-weſt courſe: the latitude and longitude of the ſecond place is demanded.

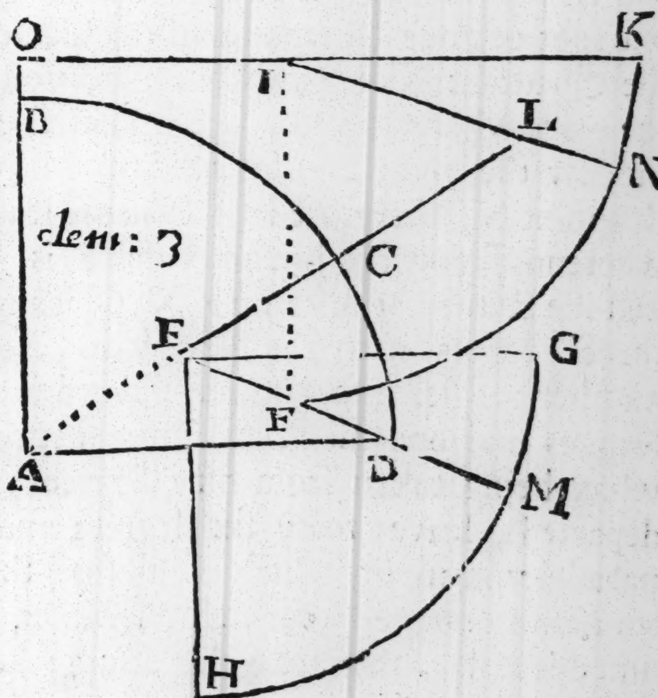
IN the ſecond Demonſtration, draw the Quadrant A B C D E, as is formerly taught; then in regard you ſail South-weſt, take four points of the Compaſs from your Scale, and place them from B unto D, then by the point D draw the line A D F, then place your ninety nine leagues upon the line A D F, from A unto F, ſo ſhall F be the place of your ſhip. Then from F draw the line F C parallel unto A E, cutting the line A B C in C, ſo ſhall the diſtance C A be the leagues you have run South, which is 70 leagues, or 3 deg. 30 min. which being added to the latitude from whence you departed, makes 64 deg. and 21 min. for the latitude of the ſecond place: then take the diſtance C F, and apply it unto the line of equal parts, and you ſhall find it likewiſe 70 leagues: Then finding the middle latitude 62 degrees 36 minutes in the Table, Chap. 14. you ſhall find that 9 leagues, and 0 miles, and 61 parts, do alter a degree of longitude in that latitude. Then opening the feet of your Compaſſes to 9 leagues, and 0 miles, 61 parts, in the Scale of equal leagues, and keeping the Compaſſes at that diſtance, ſee how many times that diſtance is in the line C F, which is ſeven times and ſomewhat above an half, the true difference of longitude being 7 deg. 36 min. which being ſubſtracted from the longitude from whence you departed, leaves 17 degrees and 48 minutes for the longitude of the ſecond place.



CHAP. XVII.

A Ship sailing from the North Parallel of fifty degrees, having an hundred leagues to sail South-west and by West, by the way is enforced by contrary winds to sail upon several points of the Compass, first sailing thirty leagues upon a direct course, then West North-west twenty leagues, then South sixty leagues; the question is to find the latitude of the second place, how far it is to the place whereunto you are bound, the distance of the Rumb that is betwixt them, the distance that you are from your first Meridian, and thereby the difference of longitude?

IN the third demonstration draw the line A D, and from the point A, raise the perpendicular A B, then open your Compass unto the Radius of your Scale, and place one foot thereof in the center A, and with the other draw the Quadrant B C D, then take three points of the Compass, and place them upon the Quadrant from D unto C, then from the center A, by the point C, draw the line ACL 100 leagnes in length, which is the true course you are to sail; Then in regard you sailed thirty leagues direct, take thirty leagues from your Scale of equal parts, and place them upon the line A E C, it extends from A unto E: then in regard you turned your Course West North-west, from the Center E, draw

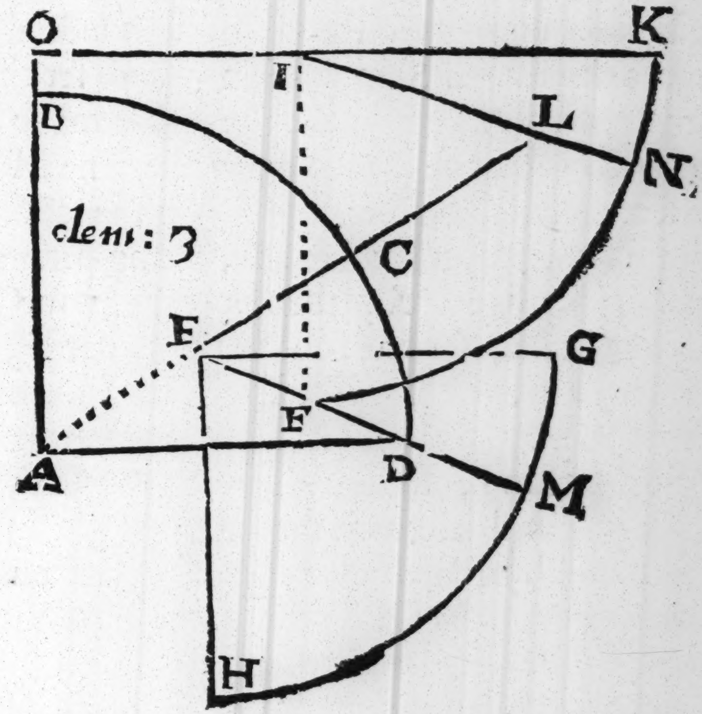


the Line E G parallel to A D: and again, from the Center E draw the line E H perpendicular to E G; and parallel to A B, then with

with the distance of the Radius, set one foot of your compasses in the center E, and with the other draw the Quadrant G M H, and in regard you sailed West Northwest, which is two points from the West Northward, take from your Scale two points of the Compass, and place them upon the Quadrant G M H, from G unto M, then from the center E unto the point M draw the line E F M, then take 20 leagues with your Compasses from the scale of equal parts, and place them upon the line E F M, from E unto F, then is your Ship in the point F. Lastly, in regard you run South 60 leagues from F, draw a line parallel unto the Meridian A B, which is the line F I, then take from your Scale of equal parts 60 leagues, and place them from F unto I, then is your Ship in the point I: then last of all is to be found how far it is to the place whereunto you are bound, the distance of the Rumb that is betwixt you, the degrees and minutes you have raised the Pole, the distance of departure from the first Meridian, and thereby the difference of longitude: and that you may so do, first draw the line O I K perpendicular unto the line I F in the point I, and with your Compasses opened unto the distance of the Radius, set one foot of your Compasses in the Center I, and with the other draw the Quadrant K N F, then regard your Ship is in the point I, and the place whereunto you are bound is the point L, therefore from I thorow the point L draw the line I L N, cutting the arch K N F in the point N, therefore let I L be the leagues you have unto the place whereunto you are bound, which is forty one leagues and a half, and the Rumb the distance K N, which is West and by North, and three degrees unto the Nothward, so likewise is the line A O the number of leagues you have run due South, which is sixty eight leagues and one mile, or three degrees and twenty five minutes, which being taken from fifty degrees, the parallel from which you departed, leaves forty six degrees and thirty five minutes for the parallel you are in. Last of all shall the line I O be the leagues that you have departed your first Meridian, which are forty two leagues and one mile; then take the middle latitude, which is forty eight degrees seventeen minutes; and in the Table chap. 14. you shall find that thirteen leagues, 0 mile, 92 parts, do answer unto a degree of longitude in that parallel; then setting one foot of your Compasses

in

in thirteen leagues, and ninety two parts, extending the other to the beginning of the Scale, keeping the Compasses at that distance, turn them over the line I O, and you shall find it contains that distance three times and almost a quarter; so the difference of longitude is three degrees eleven minutes.



CHAP. XVIII.

Two Ships departing from one Parallel and Port, the one in sailing eight leagues betwixt the North and the West, hath raised the Pole two degrees; the other in sailing an hundred leagues betwixt the North and West, hath raised the Pole four degrees, I demand by what Rumbs the said Ships have sailed, and the Rumb and distance that is betwixt them?

IN the fourth Demonstration, draw the Quadrant A B C D E, then in regard the first Ship hath raised the Pole two degrees; which is forty leagues, take forty leagues off your Scale, and apply them unto the Meridian line A G L, from A unto G: then from the point G, draw the line G F parallel unto A B, then opening your Compasses unto 80 leagues, set one foot in the Center A, with the other make a mark in the line G F, which will be at F, so shall F be the place of the first ship; the second Ship hath raised the Pole four degrees, which is 80 leagues, therefore place 80 leagues upon the Meridian line A G L, from A unto L, and from the

point

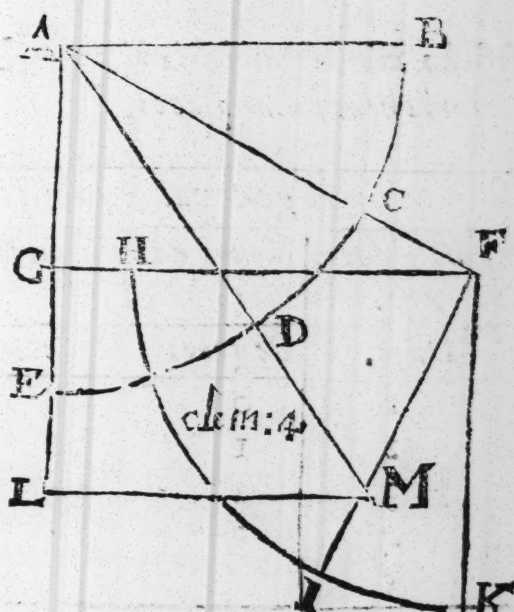
point L draw the line L M parallel unto G H F, then open your Compaſſes unto the diſtance of a hundred leagues, which are the leagues the ſecond Ship did run; and ſet the foot of your Compaſſes in the center A, and with the other make a mark in the line L M, which will be at M, then draw the line M A, which is the courſe of the ſecond Ship, and the line F A is the courſe of the firſt Ship; then from F let a perpendicular fall, being perpendicular to the line G F, which is the line F K, then opening you Compaſſes unto the Radius of your Scale, ſet one foot in the center F, and with the other draw the Quadrant H I K; likewiſe from F, the place of the firſt ſhip, draw a line by the point M, the place of the ſecond, cutting the Quadrant K H I in I, ſo let I K be the courſe that is betwixt them, that is, if you will ſail from the firſt ſhip unto the ſecond, you muſt ſail North and by Eaſt, and one and forty minutes to the Eaſtward; likewiſe let F M be the diſtance that is betwixt them; which in this Demonſtration is forty Leagues, two Miles, ſo ſhall B C be the courſe of the firſt Ship from the Weſt Northward, which here is found to be thirty degrees and one minute from the Weſt Northward, or North-weſt by Weſt, and three degrees forty four minutes to the Weſtward. Laſtly, the arch E D is in the diſtance of the courſe that the ſecond ſhip made from the North Weſtward, which is found by this Demonſtration to the Northweſt and by North, and three degrees five minutes to the Weſtward.

CHAP. XIX.

Two Ships departing from one Parallel and Port in the Parallel of 47 deg. 56 min. the firſt in ſailing 80 leagues betwixt the North and Weſt, hath raiſed the Pole two degrees: I demand by what courſe the ſecond Ship muſt run, and how much ſhe ſhall alter in her firſt Meridian or Longitude, to bring her ſelf 40 leagues and two miles North and by Eaſt, and 41 minutes to the Eaſtward of the firſt Ship?

IN the fourth Demonſtration draw the Quadrant A B C D E, then multiply your two degrees you have altered your latitude by twenty, and make it forty Leagues; which forty Leagues ſet

ſet upon the line A E L, from A unto G; then from the point G draw the line G F parallel unto A B, then open your Compaſſes unto the diſtance of 80 leagues, which are the leagues your firſt ſhip did run, and place one foot of your Compaſſes in the center A, and with the other make a mark in the line G F, which will be at the point F; then from the center A unto the point F, draw the line A F, repreſenting the diſtance of the Courſe of the firſt Ship 80 leagues: Then from F let fall a perpendicular F K, and upon the Center F, with the Radius of the Scale draw the arch H I K; then in regard you muſt bring the ſecond ſhip North and by Eaſt, and 41 minutes Eaſtward of the firſt Ship; take 11 degrees 56 minutes from your Scale of Chords, and place them from K unto I, upon the Quadrant K I H. Then from F draw the line I F, and upon the line F I place the diſtance that you muſt bring the ſecond ſhip from the firſt (which is forty leagues and two miles) from F unto M. So is M the place of your ſecond ſhip.



Then from M draw the line M L parallel unto F G, cutting the line A G L in L, then draw the line M A, cutting the Quadrant B D E in D. So ſhall the arch D E be the courſe that the ſecond ſhip muſt run, to bring her ſelf 40 leagues and 2 miles North and by Eaſt, and 41 min. Eaſt of the firſt ſhip. Then to know what you have altered the latit. firſt take the diſtance L A, and apply it unto the Scale of equal parts, and you ſhall find it to be 80 leagues, which is juſt 4 degrees which you have altered your latit. or Poles elevation: which 4 degrees added unto the latitude you departed from, it makes 51 deg. 56 min. for the latitude that your ſecond ſhip is in; then take the diſtance L M, and apply it to the Scale, it gives 60 leagues; then open your Compaſſes unto the diſtance of the middle latitude, which is 49 deg. 56 min. of the Chord, and apply it unto the Table of longitudes, and it gives 12 leagues, and 2 miles, and 62 parts, to alter one deg.

of longitude in that Parallel: Then ſet one foot of your Compaſſes in 12 leagues 2 miles and 62 parts, and open the other to the beginning of the line, and with that diſtance meaſure the line L M, being 60 leagues, and you ſhall find that it is contained there in four times and two thirds, ſo the longitude is 4 degrees 40 minutes.

CHAP. XXI.

Of the Ebbing and Flowing of the Sea, and of the Tides, and how to find them in all places.

A general Table for the Tides in all places.

The Moons age.	*Hours and minutes to be added.*		*The Moons age.*	*Hours and Minutes to be added.*	
Days.	*Degrees*	*Minutes*	*Days.*	*Degrees*	*Minutes*
1	0	48	16	0	48
2	1	36	17	1	36
3	2	24	18	2	24
4	3	12	19	3	12
5	4	0	20	4	0
6	3	48	21	4	48
7	5	36	22	5	36
8	6	24	23	6	24
9	7	12	24	7	12
10	8	0	25	8	0
11	8	48	26	8	48
12	9	36	27	9	36
13	10	24	28	10	24
14	11	12	29	11	12
15	0	0	30	0	0

The Use of the Table of the Tides.

FIrst it is to be understood, that by the swift motion of the first Mover, the Moon and all the rest of the Stars and Planets are turned about the World in four and twenty hours, upon which swift motion of the Moon, the daily motions of the Sea do depend; which motion of the Sea falleth not out always at one hour, the reason thereof is, because of the swift motion of the Moon, in regard she goeth almost thirteen degrees in four and twenty hours, and the Sun moveth scarce one degree, which gives every day twelve degrees, that the Moon cometh slower to any point in the Heaven than the Sun; which twelve degrees, makes forty eight minutes of time for the difference of every full Sea, according unto the middle motion of the Moon, which difference is here set down in this Table for every day of the Moons Age. Therefore if you would know the full Sea at any place in the World, first you must know at what hour it is full Sea at the new or full Moon; which hours and minutes keep in mind, then seek the age of the Moon, as is before taught, and with the number of her age enter this Table under the Title of the Moons age; and having found her age in the Table, against it you shall find the hours and minutes which are to be added unto the time that the Moon maketh full Sea in any place, and the whole number of hours and minutes is the time that the Moon maketh full Sea in that place upon the day desired: as for example, I desire to know the full Sea at *London-Bridge* upon the thirteenth of *July* 1624. the age of the Moon being found as before, is eight days, then in the Table I find eight days, and against it 6 hours, and 24 minutes, which being added unto three hours, the full Sea upon the change day, gives 9 a clock 24 minutes, for the time at the full Sea upon the 13 day of *July*, 1624.

THE

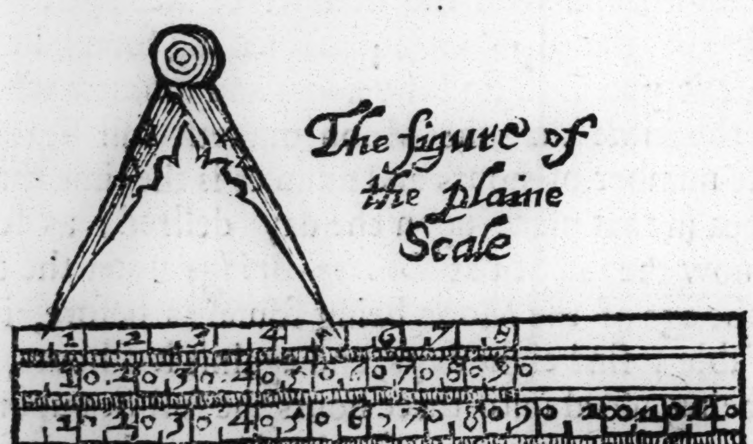
THE SEA-MANS GLASS.

The Second Book.

Wherein is declared the Definition of the Sphere, a Deſcription of the ſix great Circles, and alſo of the four leſſer Circles. Laſt of all, certain Queſtions Aſtronomical, performed by the ſaid Scale.

CHAP. I.

Of a Sphere, and the Circles thereof.



A *Sphere*, according to the Deſcription of *Theodoſius*, is a certain ſolid Superficies, in whoſe middle is a Point, from which all lines drawn unto the Circumference are equal; which Point is called the Center of the Sphere; by which Center a right Line being drawn, and extending bimſelf on either ſide unto that part of the Circumference whereupon the Sphere is turned, is called *Axis Sphera*, or the Axle-tree of the World.

A *Sphere* accidentally is divided into two parts, that is to say, *in Sphæram rectam & Sphæram obliquam.*

Sphera recta, or a right Sphere, is only unto those that dwell under the *Equinoctial, Quibus neuter Polorum magis altero elevatur:* that is, to whom neither of the Poles of the World are seen, but lie hid in the *Horizon.*

Sphera obliqua, or an oblique Sphere, is unto those that inhabit on either side of the *Equinoctial*; unto whom one of the Poles is ever seen, and the other hid under the *Horizon.*

The Circles whereupon the Sphere is composed, are divided into two sorts; that is say, *in Circulos majores & minores.*

Circuli majores, or the greater Circles, are those that divide the Sphere into two equal parts, and they are in number six, *viz.* the *Equinoctial*, the middle of the *Zodiack* or the *Eclip tick* line, the two *Colures*, the *Meridian*, and the *Horizon.*

Minores vero Circuli, or the lesser Circles, are such as divide the Sphere into two parts, unequally, and they are four in number, as the Tropick of *Cancer*, the Tropick of *Capricorn*, the Circle *Artick*, and the Circle *Antartick.*

CHAP. II.

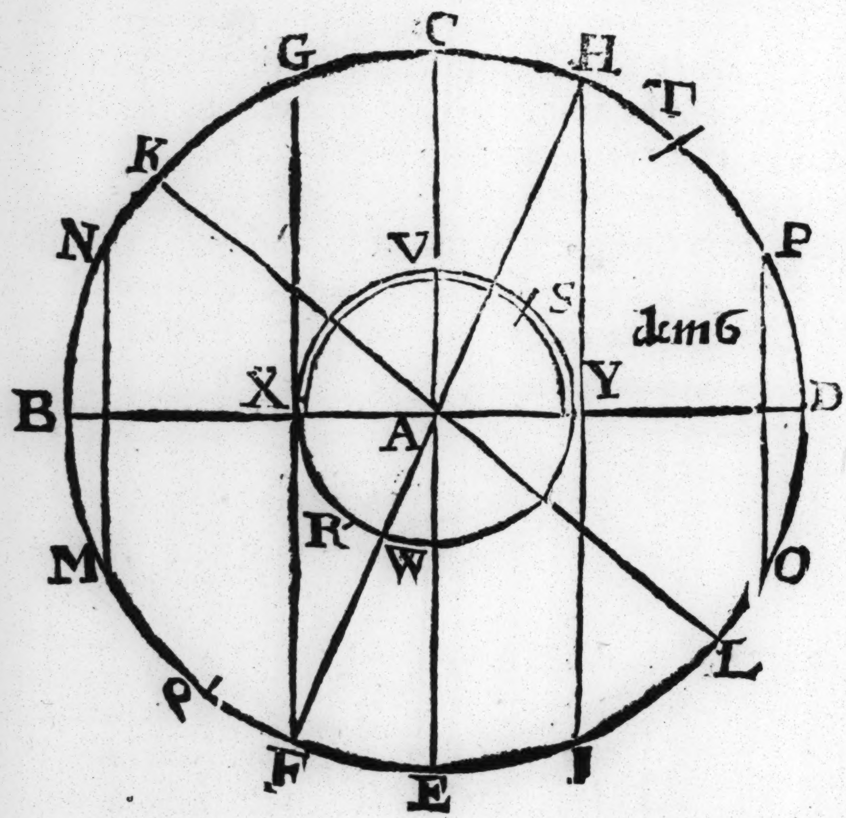
Of the six great Circles.

I. THe *Equinoctial* is a Circle that crosseth the Poles of the World at right Angles, and divideth the Sphere into two equal parts, and is called the *Equinoctial*, because when the Sun cometh unto it, (which is twice in the year, *viz. In principio Arietis & Libræ*, that is, in *March* and *September*) the Days and Nights are equal throughout the whole World, whereupon it is called *Equator diei & noctis*, the equal proportioner of the Day and Night artificial; and in the figure is described by the line C A E.

II. The *Meridian* is a great Circle passing thorough the Poles of the World, and the Poles of the *Horizon*, or *Zenith* point over our heads; and is so called, because that in any time of the year, or in any

any place of the World, when the Sun (by the motion of the Heavens) cometh unto that Circle, it is noon, or 12 of the Clock. And it is to be understood, that all Towns and places that lie East and West one of another, have every one a several Meridian: but all places that lie North and South one of another, have one and the same Meridian. This Circle is declared in the figure following, by the Circle BCDE.

III. The *Horizon* is a Circle dividing the superior *Hemisphere* from the inferiour, whereupon it is called *Horizon*, that is to say, the bounds of sight, or the farthest distance that the eye can see, and therefore it is also called *Circulus hemisphari.* The *Horizons* are divided into two sorts, viz. *Rectus & Obliquus*, a Right and an Oblique, or a declining *Horizon:* whereof those have a Right *Horizon* which have the *Equinoctial* for their *Zenith*, & the Poles of the World in their *Horizon:* because the *Horizon* (hiding both the Poles of the World) is a Circle supposed to be drawn by the Poles of the World, dividing the *Equinoctial* at right angles, as in the Figure foregoing you may plainly see. First imagining the Circle XVYW to be the Earth, and those that inhabit at the point V have the line BD for their *Horizon*, cutting the *Equinoctial* CAE at right Angles in A, and therefore is called *Horizon rectus & Sphera recta*, a right *Horizon*, and a right



Sphere.

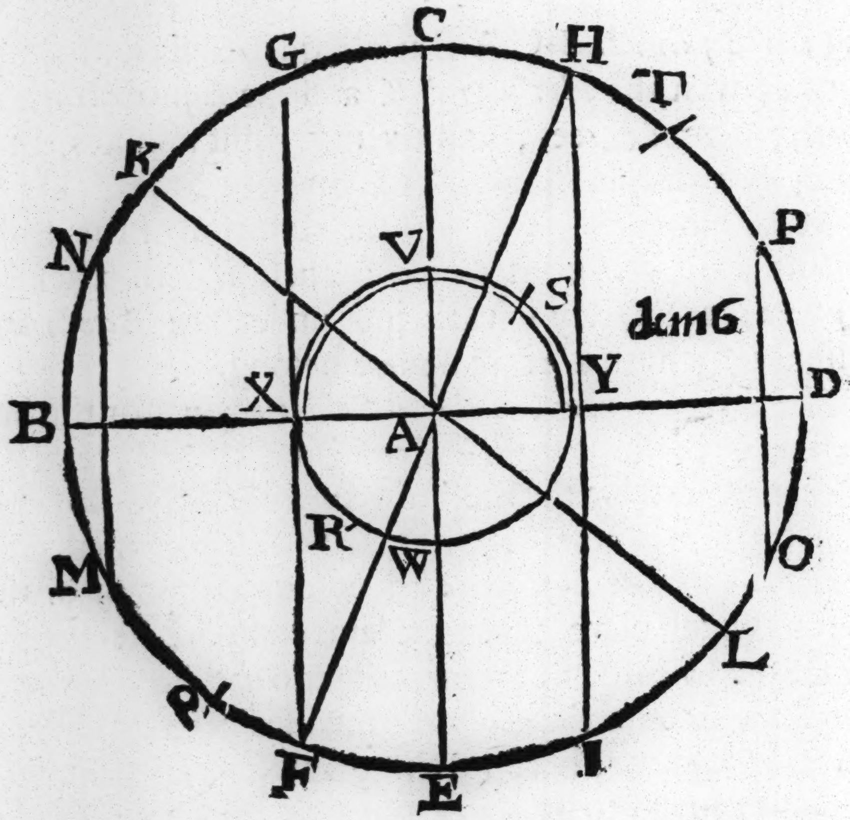
Sphere. Those have an oblique *Sphere*, or an oblique *Horizon*, to whom one of the Poles are visual, or elevated above the *Horizon*, and have the other ~~hid~~ under the *Horizon*; and in regard such a *Horizon* doth cross the *Equinoctial*, or oblique Angles, it is called *Horizon obliquus*, or a declining *Horizon*: as for example, Those that inhabit at the point S, have T for their *Zenith*, and K A L for their *Horizon*, dividing the *Equinoctial* C A E at oblique Angles, making the Angle contained betwixt the *Horizon* A K and the *Equinoctial* A C, an angle of thirty eight degrees, and twenty eight minutes, and the angle contained betwixt the *Horizon* A L and the Pole A D, an angle of 51 degrees 32 minutes, which is the elevation of the Pole for those that inhabit at S, as those at *London*; these and all other have an oblique *Sphere*, except they inhabit just under the *Equinoctial* Circle, unto whom only doth a right *Sphere* belong.

IV. The two Colures, *Colurus Solstitiorum*, or the Summer Colure, is a Circle passing by the Poles of the World, and by the Poles of the Ecliptick, and by the head of *Cancer* and *Capricorn*, whereupon the first scruple of *Cancer*, where the Colure crosseth the Ecliptiek Line, is called *Punctus Solstitiæ æstivalis*, or the point of the Summer Solstice: to which place, when the Sun cometh, he can approach no nearer unto our *Zenith*, but returneth unto the *Equator* again. *Arcus vero Coluri*, the Arch of the Colure, contained betwixt the Summer Solstice and the *Equator*, is called the greatest declination of the Sun, which *Ptolomy* found to be 23 degrees, 31 minutes: *but by the observation of* Copernicus *it was found to vary, for he found the declination sometimes to be 23 degrees 52 minutes, and in the process of time, to be but 23 degrees 28 minutes. And in these our days (by the observation of* Tycho de Brache, *and the late famous Mathematician Mr.* Edward Wright) *it is found distant from the* Equinoctial 23 *degrees, 31 minutes, 30 seconds.*

V. The other Colure passeth by the Poles of the World, and by the first point of *Aries* and *Libra*, whereupon it is called *Colurus distinguens Equinoxia.* These two Colures do cross each other at right angles in the Poles of the World, whereupon these Verses were made.

Hæc duo Solstitia faciunt Cancer Capricornus,
Sed noctes æquant Aries & Libra *diebus.*

VI. The Zodiack is another of the greater Circles, dividing the *Equinoctial* into two equal parts by the head of *Aries* and *Libra*, the one half of it doth decline unto the North, and the other unto the South, the greateſt of whichdeclinations is 23 degrees, 31 m. and 30 ſ.



Note alſo, this Circle is divided into twelve equal parts, which parts are attributed unto the twelve Signs, *Aries*, *Taurus*, *Gemini*, *Cancer*, *Leo*, *Virgo*, *Libra*, *Scorpio*, *Sagitarius*, *Capricornus*, *Aquarius*, and *Piſces*. And every one of theſe Signs are divided into 30 equal parts, which are called degrees; ſo the whole Zodiack containeth three hundred and ſixty degrees. Likewiſe every degree is divided into ſixty equal parts, which parts are called minutes, and are in number 21600 minutes; and as 21600 minutes is the whole circumference of the Heavens, ſo is 21600 miles the whole circuit of the Earth.

CHAP.

CHAP. III.

Of the four lesser Circles.

THe Sun having ascended unto his highest Solstitial point doth describe a Circle, which is the nearest that he can approach unto the North Pole, whereupon it is called *Circulus Solstitii æstivalis*, the Circle of the Summer Solstice, or the Tropick of *Cancer*, and is noted in the figure before by the line H Y I.

The Sun also approaching unto the first scruple of *Capricornus*, or the Winter Solstice, describeth another Circle, which is the utmost bounds that the Sun can depart from the Equinoctial Line towards the Antartick Pole, whereupon it is called *Circulus solstitii hyemalis, sive Tropicus hyemalis, vel Capricorni*, the Circle of the Winter Solstice, the Winter Tropick, or the Tropick of *Capricorn*, and is described in the figure by the line G X F.

So much as the Ecliptick declineth from the Equinoctial, so much doth the Poles of the Ecliptick decline from the Poles of the World, whereupon the Pole of the Ecliptick, which is by the North Pole of the World, describeth a certain Circle as it passeth about the Pole of the World, being just so far from the Pole, as the Tropick of *Cancer* is from the Equator, and it is the third of the lesser Circles, and is called *Circulus Arcticus*, or the Circle of the North Pole, and is described in the *Diagram*, in the second Chapter by the line P O.

The fourth and last of the lesser Circles, is described in like manner by the other Pole of the Ecliptick, about the South Pole of the World, and therefore called *Circulus Antarcticus*, the Antarctick Circle, or the Circle of the Antartick or South Pole, and is demonstrated in the former figure, by the line N M.

CHAP. IV.

Definitions of some particular terms fit to be known by such as intend to practice the Art of Navigation or Astronomy.

THe Zenith is an imaginary point in the Heavens over our heads, making right angles with the Horizon, as the Equinoctial maketh with the Pole.

The *Nadir* is a prick in the Heavens under our feet, making right angles with the Horizon under the Earth, as the Zenith doth above, and therefore is opposite unto the Zenith.

The declination of the Sun is the Arch of a Circle contained betwixt the place of the Sun in the Eclipτick and the Equinoctial, making right angles with the Equinoctial But the declination of a Star is the Arch of a Circle let fall from the Center of a Star, perpendicularly unto the Equinoctial.

The Latitude is the arch of a circle contained betwixt the Center of any Star and the Ecliptick line, making right angles with the Ecliptick, and counted either Northward or Southward, according to the situation of the Star, whether it be nearer unto the North or South Pole of the Ecliptick.

The Latitude of a Town or Country is the height of the Pole above the Horizon, or the distance betwixt the Zenith and the Equinoctial.

The Longitude of a Star, is that part of the Ecliptick which is contained betwixt the Stars place in the Ecliptick, and the beginning of *Aries*, counting them from *Aries*, according to the succession or order of the Signs.

The Longitude of a Town or Countrey are the number of degrees which are contained in the Equinoctial, betwixt the Meridian that passeth over the Isles of *Azores*, (from whence the beginning of longitude is accounted) Eastwards, and the Meridian that passeth over the Town or Country desired.

The Altitude of the Sun or Star is the arch of a Circle contained betwixt the Center of the Sun, or any Star, and the Horizon.

The

The Amplitude is that part of the Horizon which is betwixt the true Eaſt or Weſt points, and the point of the Compaſs that the Sun or any Star doth riſe or ſet upon.

Azimuth's are Circles which meet together in the Zenith, and croſs the Horizon at right angles, and ſerve to find out the point of the Compaſs which the Sun is upon at any hour of the day; or the Azimuth of the Sun or Star, is a part of the Horizon contained betwixt the true Eaſt and Weſt point, and that Azimuth which paſſeth by the Center of the ſame Star to the Horizon.

The right aſcenſion of a Star is that part of the Equinoctial that riſeth or ſetteth with the Star in a right Sphere: or in an oblique Sphere, it is that proportion of the Equinoctial, contained betwixt the beginning of *Aries*, and that place of the Equinoctial which paſſeth by the Meridian with the Center of the Star.

The oblique aſcenſion is a part of the Equinoctial, contained betwixt the beginning of *Aries*, and that part of the Equinoctial that riſeth with the Center of a Star in an oblique Sphere.

The difference aſcenſional, is the difference betwixt the right and oblique aſcenſion: or it is the number of degrees contained betwixt that place of the Equinoctial that riſeth with the Center of a Star, and that place of the Equinoctial that cometh unto the Meridian with the Center of the ſame Star.

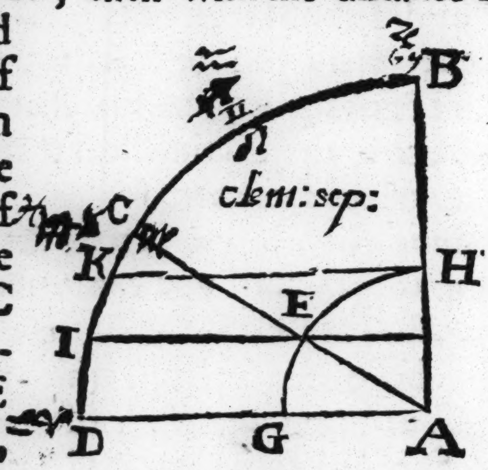
Almicanterahs are Circles drawn parallel unto the Horizon, one over another, until you come unto the Zenith: theſe are Circles that do meaſure the elevation of the Pole, or height of the Sun, Moon, or Stars above the Horizon, which is called the Almicanter of the Sun, Moon, or Star: the Arch of the Sun or Stars Almicanter, is a portion of an Azimuth contained betwixt that Almicanter which paſſeth thorow the Center of the Star and the Horizon.

QUESTIONS ASTRONOMICAL, performed by the plain Scale.

CHAP. V.

The true place of the Sun being given, to find his declination.
The Sun being in the head of Taurus, *his declination is deſired.*

BY the ſeventh Demonſtration draw the line A D, then upon the Center A raiſe the perpendicular A B, then opening your Compaſſes to the Radius of your Scale, place one foot in the Center A, and with the other draw the Quadrant BCD, then opening your Compaſſes unto the greateſt declination of the Sun, place it upon the Quadrant from D unto K, then from the point K draw the line K H parallel to D A, cutting the line A B in H, then with the diſtance A H draw the ſmall Quadrant G E H, and in regard the Sun is in the head of *Taurus*, which is 30 degrees from the beginning of *Aries*, let A D be the Equator, and D the beginning of *Aries*, D C 30 degrees, or longitude of the Sun, then from the point C draw the line C A, cutting the Quadrant G E H in E, then from E draw the line E I parallel to A D, cutting the Quadrant B C D in I,



ſo ſhall the arch I D be the declination of the Sun deſired, which in this Demonſtration is found to be eleven degrees, and thirty one minutes.

CHAP. VI.

The declination of the Sun, and quarter of the Ecliptick that he possesseth, being given, it is desired to find his true place.

The declination is 10 *deg.* 31 *min. the first quarter that he possesseth, is betwixt the head of* Aries *and* Cancer.

FIrst by the seventh Demonstration, draw the Quadrant A B C D, as is taught in the former Chapter, then set the greatest declination of the Sun upon the Chord from D unto K, which is 23 deg. and 31 min. then from K draw the line K H parallel unto the *Equator* D A, cutting the line B A in the point H. So shall H A be the sign of the Suns greatest declination; then with the distance A H draw the Quadraut G E H, then from D upon the Quadrant D B C set the Declination of the Sun, which is 11 degrees, 31 minutes from D unto I, then draw the line I E parallel unto A D, cutting the Quadrant G E H in E. Then from the center A by the point E, draw the line A E C, cutting the Quadrant B C D in C. So shall the Arch C D be the distance of the Sun from the head of *Aries*, which is here found to be just 30 degrees, which is in the beginning of *Taurus*.

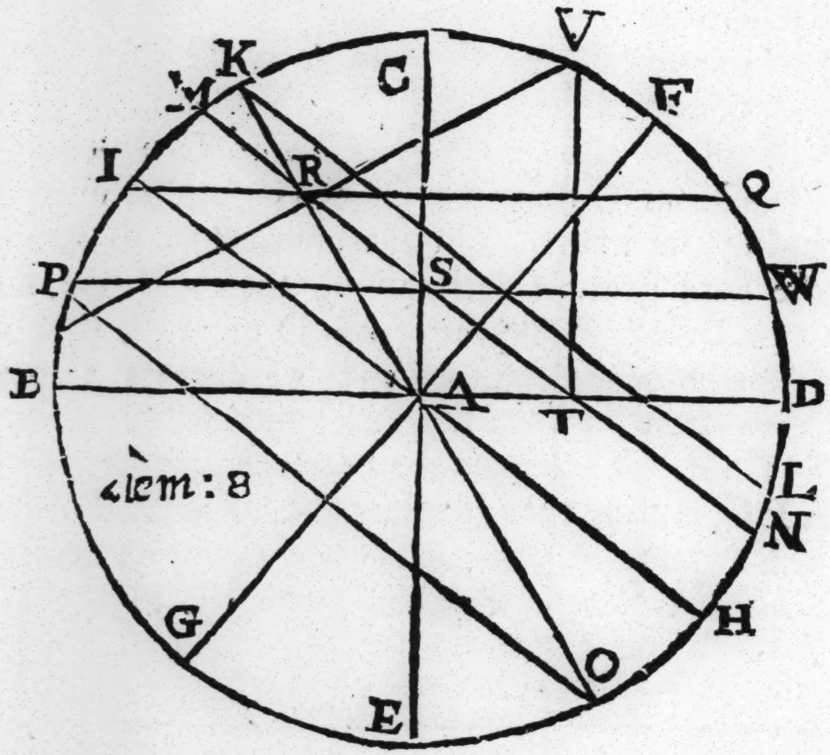
CHAP. VII.

By the elevation of the Pole, and declination of the Sun, to find the amplitude of the Sun, or his distance of rising or setting from the true East or West point.

The elevation of the Pole is 51 *deg.* 32 *min. the declination of the Sun is* 14 *deg.* 52 *min. North.*

BY the eight Demonstration, first draw the line B D, then upon the Center A draw the Circle B C D E, then from A raise the perpendicular C A E, then is your Circle divided into four equal parts: then suppose the elevation of the Pole to be

be 51 degeees, 32 minutes, which must be placed upon the Circle, from D unto F, then from the point F by the center A draw the line F A G, representing the Pole of the World, F being the North Pole, and G the South Pole; then substract 51 deg. 32. min. from 90 deg. and the remainder is the height of the Equinoctial, which is 38 deg. 28 min. which must be placed upon the Circle from the Horizon B unto



the point I, then from I, by the Center A draw the line I A H, representing the Equinoctial Circle. Then from I unto M set the declination of the Sun, being here supposed 14 deg. 52 minutes North, then from the point M draw the line, or Parallel of Declination M T N, parallel unto the Equator I A H, cutting the Horizon B D in T, then from T raise the perpendicular T V, cutting the Circle B C D E in V, so shall the distance C V be the true amplitude of the Sun desired, which here is found to be 24 deg. 21 minutes North.

CHAP.

CHAP. VIII.

By the Amplitude of the Sun, to find the variation of the Compass.

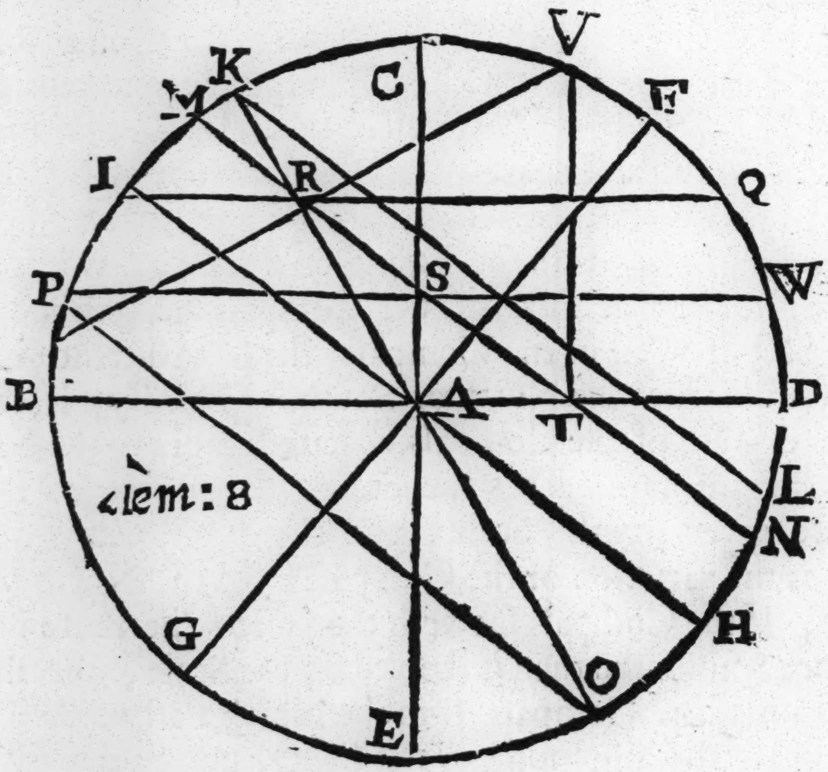
HAving found the amplitude of the Sun by the last Chapter, first observe with a Compass, or rather with a Semicircle, upon what degree and minute the Sun riseth or setteth, beginning to reckon from the East or West, and ending at the North or South at 90 degrees: and when you have diligently observed the Magnetical rising or setting by the Semicircle, or by some other like fitting Instrument: and also the true amplitude found, as is declared in the last Chapter, the difference of these two amplitudes, is the variation of the Compass: But when the Sun riseth upon the same degree of the Compass as is found by the Scale, the variation is nothing but the Needle pointeth directly unto the Poles of the World, which by M. *Moulineux* was affirmed to be at the Westermost part of St. *Michaels*, one of the Islands of the *Azores*, from whence he will have the Longitude reckoned. Secondly, when the Sun is in the Equinoctial Circle, where he hath no amplitude, look what distance the Compass maketh the Sun to rise from the East or West of the Compass, the same distance is the Compasses variation from the North or South. Thirdly, If the Sun rise more to the South of the Compass, or setteth more to the North of the Compass than is shewed by the Scale, the difference betwixt the Amplitude given by the Scale, and the Amplitude given by the Needle, is the variation of the Compass from the North Westward. Fourthly, If the Compass sheweth the Sun to rise more Northward, or set more Southward than is shewed by the Scale, the difference is the variation of the Compass from the North Eastward. Fifthly, If the Scale shew the amplitude of the Sun rising Southerly, and the Compass shew it to be Northerly, add both the amplitudes together, and they shew you the variation Westerly.

CHAP. IX.

The place of the Sun being given, to find his declination, by a whole Circle.

The Suns place is the tenth degree of Taurus.

According unto the eighth Demonstration, first draw the Circle ABCDE, then draw the Horizon BAD, and then the Equinoctial IAH, as is before taught: and then the Tropick of *Cancer* KL twenty three degrees and an half from the Equinoctial: then draw the Tropick of *Capricorn* PO, of like distance from the Equinoctial,



and after from K to O draw the Ecliptick line KAO. And when you have thus laid down the Sphere, suppose the Sun to be in the tenth degree of *Taurus*, at which time his declination is desired. And in regard the Sun is more near unto the Tropical point *Cancer* than unto *Capricorn*, first find how many degrees he is from the Tropick of *Cancer*,

cer, and you shall find him to be 50 degrees; therefore take with your Compasses 50 degrees from the Chord, and apply it from the Tropical point *Cancer* at K unto V upon one side, and unto P on the other side; then draw the line V P, cutting the Ecliptick K O, in the point R, then from R draw the line M R N parallel unto the Equinoctial IAH, and cutting the Quadrant B C in the point M. So shall the arch M I be the declination of the Sun desired, which being applied unto your Scale, gives 14 deg. and 52 min.

CHAP. X.

The elevation of the Pole, and declination of the Sun given, to find his height in the vertical Circle.

The Pole is elevated 51 degrees, 32 minutes, the declination of the Sun is 14 degrees 52 minutes North, his height in the Vertical Circle is found as followeth.

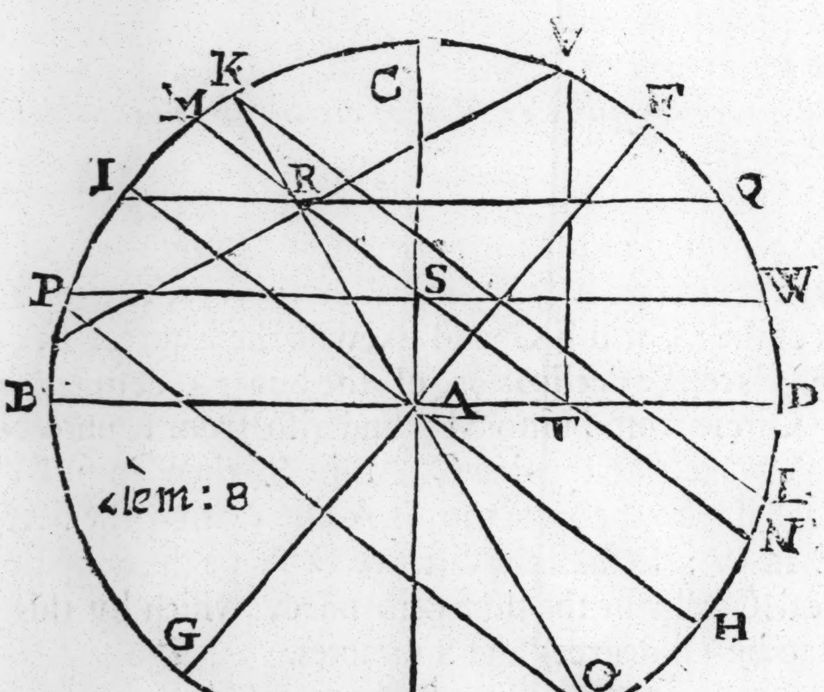
FIrst, according to the former Chapter, draw the Circle B C D E, then the Horizon B A D, and after the Vertical line C A E, then the Axis of the World F G, and likewise the Equator I A H; this being done, place the declination of the Sun 14 degrees 52 minutes, upon the Circle from I unto M, and also from H unto N, then draw the line M N, cutting the line C A E in S, then from S draw the line S W parallel unto the Horizon B A D, cutting the Meridian Circle B C D E in W: so shall the distance D W be the height of the Sun in the vertical Circle for the time demanded, which by this proposition is found to be 19 degrees and 8 minutes.

CHAP. XI.

The elevation of the Pole, and the Amplitude of the Sun being given, to find the declination.

The elevation of the Pole as 51 degrees 32 minutes, the Suns amplitude is 24 degrees 21 minutes, the declination is found as followeth.

FIrſt, As in the eight demonſtration, upon the Center A, draw the Circle B C D E, then draw the Line B A D, repreſenting the Horizon: dividing the Circle into two equal parts



then draw the Line C A E, perpendicular to B A D, repreſenting the Eaſt and Weſt points of the Compaſs, then placing the elevation of the Pole 51 degrees and 32 minutes, from D unto F, from F by the Center A draw the line F A G, which let be the Pole or Axle-tree of the World; then from B unto I, and from D unto H, ſet

set the Complement of the Poles elevation: wich shall represent the Eqinoctial, iu regard it maketh right angles with the Pole of the world in the center A. Then from C unto V place the amplitud of the Sun, wich is 24 degrees and 21 minutes: then from V let fall the perpendicular V T, cutting the Horizon B A D in the point T, then from the point T draw the line M T N parallel unto the Equinoctial I A H, and cutting the Circle B C D E in the points M and N, so shall the distance I M or H N be the declination of the Sun, which was desired: which being applied unto your Scale, gives you fourteen degrees and fifty two minutes.

CHAP. XII.

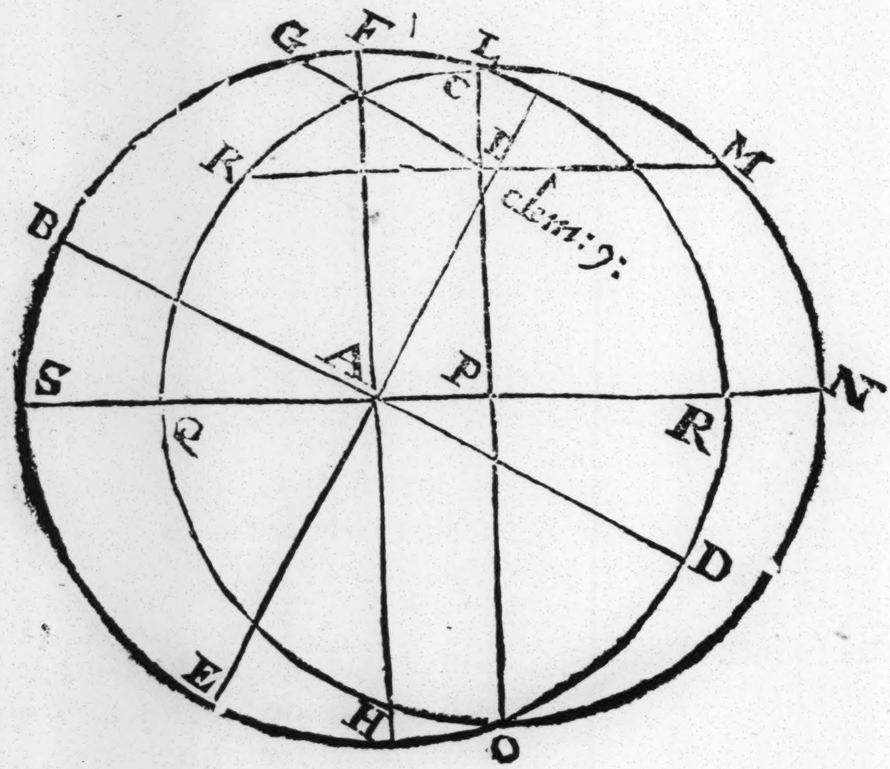
The elevation of the Pole, the declination of the Sun, and hour of the day being given, to find the Almicanter.

The elevation of the Pole is thirty degrees, the declination of the Sun is twenty degrees North, the hour is nine in the morning, at which time the Almicanter is found as followeth.

BY the ninth Demonstration, first upon the Center A draw the Circle B C D E, then draw the line B D for the Horizon, then place your Poles elevation, which is thirty degrees, upon the Circle from D unto R, then from R by the center A draw the line R A S, representing the Axis of the World, then from B unto F place the Complement of the Poles elevation, which is 60 degrees, and from the point F, by the Center A, draw the line F A H, representing the Equinoctial line, and then set the declination of the Sun from F unto L, and from L draw the line L P O parallel unto the Equator F A H, cutting the Axis of the World in the point P, then set one foot of your Compasses in the point P, and extend the other either unto L or unto O, and with the same distance of your Compasses, upon the center P draw the Circle L N O Q, whieh is called the hour Circle: so shall L be the point of twelve a clock at noon, N the place of six a clock afternoon, O the place of twelve a clock or midnight, and Q the place of six a clock

in

in the morning: Every one of the four quarters muſt be divided into ſix equal parts or hours, making the whole Circle to contain twenty four parts, repreſenting the 24 hours of the day and night; then in regard the hour of the day was nine of the clock, which is three hours before noon, take three of thoſe twenty four hours, and place them



upon the Circle L N O Q from the Meridian point L unto K, the nine a clock point in the morning, and unto M the point of three of the clock afternoon, then draw the line M K, cutting the parallel of the Sun L O in the point I, then from I draw the line I G parallel unto the Horizon B A D, which ſhall cut the Meridian Circle B C D E in the point G, ſo ſhall the diſtance of G and B, be the Almicanter of the Sun, which was deſired; which in this demonſtration is found to be forty eight degrees and eighteen minutes.

CHAP.

CHAP. XIII.

The elevation of the Pole, the Almicanter, and declination of the Sun being given, to find the hour of the day.

The elevation of the Pole is thirty degrees, the declination of the Sun is twenty degrees, the Almicanter of the Sun is forty eight degrees, and eighteen minutes, the hour of the day is found as followeth.

FIrst, as in the ninth demonstration, upon the Center A draw the Circle B C D E, then draw the Diameter B D, representing the Horizon, then from D unto R set 30 degrees, the elevation of the Pole, then from R unto the point A draw the line R A S, representing the Pole of the World, then draw the line F A H, crossing the Pole in A, at right Angles cutting the Meridian Circle in F, then from F set twenty degrees, the declination of the Sun unto L, and then from the point L, draw the line L P O, representing the parallel of the Sun, and cutting the Pole of the World in P, then placing one foot of your Compasses in P, extend the other unto L, with which distance of your Compasses draw the hour Circle L N O Q, then from the Horizon at B, place the Suns Almicanter (which is forty eight degrees, and eighteen minutes) upon the Quadrant B G L, from B unto G, then from the point G draw the line G I parallel unto the Horizon B A D, cutting the line L O in I, then from the point I draw the line K I M parallel to the Pole of the World Q A N, cutting the Circle L N O in M, then let L N be divided into six hours, whereof L M are three: whereupon I conclude, that it is three hours from noon, that is, at nine of the clock in the morning, or three in the afternoon.

CHAP. XVI.

The Latitude of the place, the Declination of the Sun, and the Altitude of the Sun being given, to find the hour of the day: By a new way, differing from that in the former Chapter.

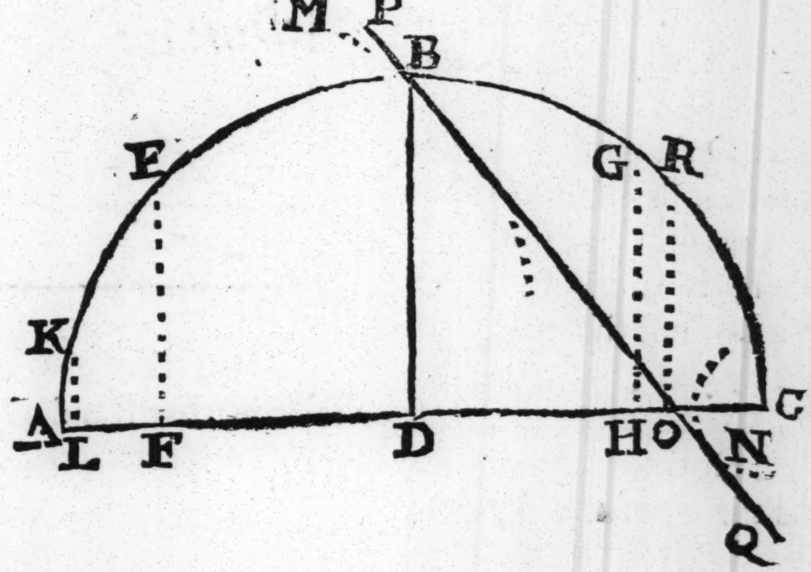
	deg.	min.		deg.	m.
The Suns ~~declination~~ Altitude is	48	18	its Compl. N.	~~60~~	~~00~~
The Latitude of the place is	30	00		60	00
The Suns ~~Altitude~~ Declination is	20	00		70	00
			Sum	130	
			difference	10	00

The Complement of any arch less than 90 degrees, is so much as the arch wants of 90 degrees: as the Complement of 20 degrees is 70 degrees, &c.

FIrst find the sum and difference of the Complement of the Suns declination, and the Complement of the Latitude, as above is done, where the sum is 130 degrees, and the difference 10 degrees. Then your Compasses being opened to the Radius of your line of Chords, describe the Semicircle A B C, and divide it into two Quadrants by the perpendicular B D, then out of your line of Chords take 48 deg. 18 min. the Suns Altitude, and set it from B to E, and draw E F parallel to B D: Then from your line of Chords take 130 deg. the sum, and set it from A to G, (or its Complement to 180 deg. which is 50 deg from C to G) and draw the line G H also parallel to B D. Again, out of your line of Chords take 10 deg. (which is the difference) and set that distance from A to K, and draw K L parallel to E F or B D.

This done, take with your Compasses the distance from F to H, and setting one foot in A, with the other describe the arch M P, likewise take the distance from F to L, and setting one foot in C, with

with the other describe the arch N Q. Lastly, Draw the straight line P Q, which only touching the two former arches will cut the line A C in O, upon the point O therefore erect the perpendicular O F, cut-



ting the Semicircle in R, so will C R being measured upon your line of Chords, give you the degrees of the Sun from the South part of the Meridian, which here you will find to be 45 degrees, which makes 3 hours, allowing 15 degrees for an hour, for 15 degrees make one hour, and one degree makes 4 minutes of an hour, so that it is either 9 of the clock in the morning, or 3 in the afternoon.

CHAP. XV.

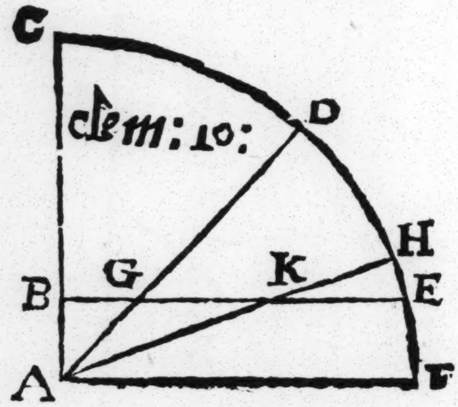
The Almicanter, or height of the Sun being given, to find the length of the right shadow.

The Almicanter is 45 degrees.

ACcording unto the tenth Diagram, draw the line A F, and upon the Center A raise the perpendicular A C, then upon the Center A draw the Quadrant C D F, then suppose the

 height

height of your *Gnomon*, or ſubſtance yielding ſhadow be the line A B, which is to be divided into 12 equal parts, which *Gnomon* I have here made juſt 12 degrees of the equal leagues of the Scale, then from B to the top of the *Gnomon* draw the line B E parallel unto A F, then ſet the Almicanter which is forty five degr. from F unto D, and from the point D draw the line D A, cutting the line B E in the point G, ſo ſhall B G be the length of the right ſhadow deſired, which here is found to be 12 parts, which is but juſt the length of your *Gnomon*, $\frac{2}{12}$ and $\frac{1}{3}$ of a twelfth over: Note that the right ſhadow is the ſhadow of any poſt, ſtuff, or ſteeple, that ſtandeth at right angles with the Horizon, the one end thereof reſpecting the Zenith of the place, and the other the *Nadir*.



CHAP. XVI.

The Almicanter, or height of the Sun being given, to find the length of the contrary ſhadow.

The Almicanter given is 70 degrees.

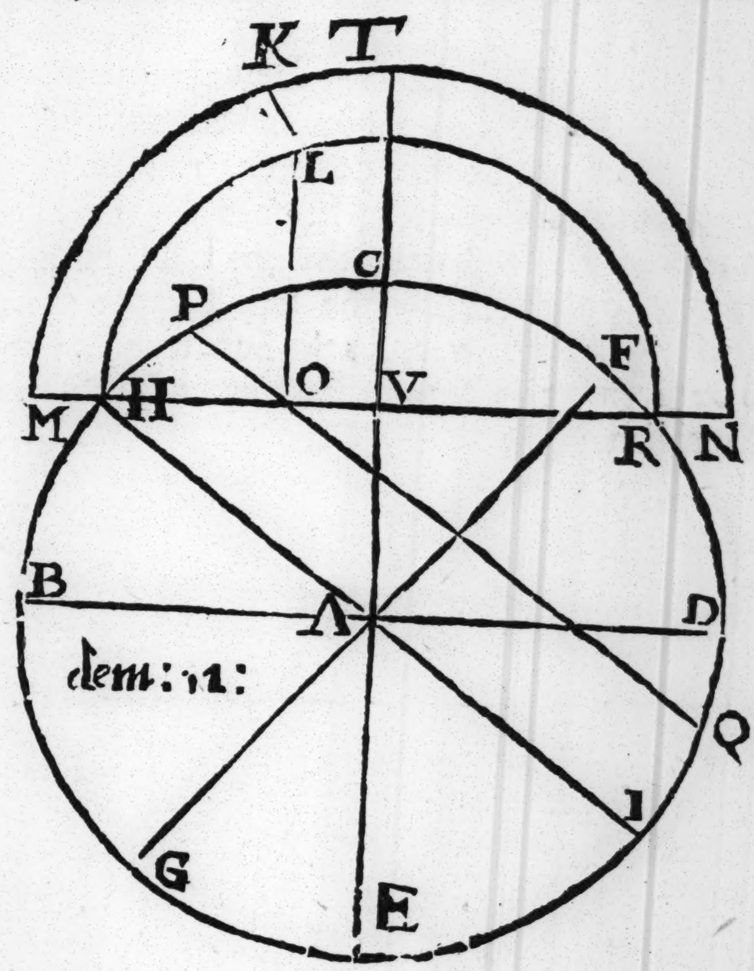
BY the verſe or contrary ſhadow, is underſtood the lengh of any ſhadow that is made by a ſtaff or *Gnomon* ſtanding againſt any perpendicular Wall; in ſuch a manner that it may lie parallel unto the Horizon, the length of the contrary ſhadow doth increaſe as the Sun riſeth in height; whereas contrariwiſe, the right ſhadow doth increaſe in length, as the Sun doth decreaſe in height: the way to find the verſe ſhadow is as followeth. Firſt, draw your Quadrant as is taught in the laſt Chapter, wherein let A B be the length of the *Gnomon*; likewiſe from B, draw the line B E parallel unto A F, as before; then ſet your Almicanter from C upon the Quadrant which is given to be ſeventy degeees, and it will extend from C unto H; then from the point H draw the line H A, cutting the line B E in the point K, ſo ſhall K B be the length

length of the contrary shadow, which here is found to be thirty four degrees and eight minutes, or twice so long as your *Gnomon*, and $\frac{10}{12}$ about $\frac{1}{2}$ part of a twelfth more.

CHAP. XVII.

The Latitude of the place, the Almicanter, and Declination of the Sun being given, to find the Azimuth.

The Latitude of the place is fifty one degrees, thirty minutes, the declination of the Sun twenty degrees North, the Almicanter thirty eight degrees thirty minutes, the true Azimuth of the Sun is desired.



First, as in the eleventh Demonstration upon the Center A, draw the Circle BCDE, then draw the Diameter BAD, and from D unto F, set the Elevation of the Pole, which is

one and fifty degrees, and thirty minutes, whoſe complement is eight and thirty degrees and thirty minutes, which muſt be placed from B unto H, then from H draw the line H A I, repreſenting the Equinoctial line, and from F draw the line F A G, repreſenting the Pole of the World, then from H unto P, and from I unto Q, ſet the Declination of the Sun, which is twenty degrees, and by theſe two points draw the line P Q, for the parallel of the Suns declination; then upon the Circle from B unto H ſet the Suns Almicanter, thirty eight degrees and thirty minutes; then from H draw the line H R parallel unto the Horizon cutting the Suns parallel P O Q in O, then draw the line T V A E perpendicular unto the line B A D in the Center A, and cutting the line H V R in V, then ſetting one foot of your Compaſſes in the point V, extend the other unto R, and with the ſame diſtance draw the Semicircle H L R, then draw the Concentrick Circle upon the Radius of the Scale M T N, and where the line P O Q, and the line M O N do meet in the point O, raiſe the perpendicular O L, cutting the Semicircle H L R in L, then lay the Scale from the Center A to the point L, and draw the line L K, cutting the Semicircle M T N in K, ſo ſhall M K be the true diſtance of the Sun from the Eaſt or Weſt point Southward, or the Suns true Azimuth, which is here found to be ſeventy two degrees and forty minutes from the South part of the Meridian.

CHAP.

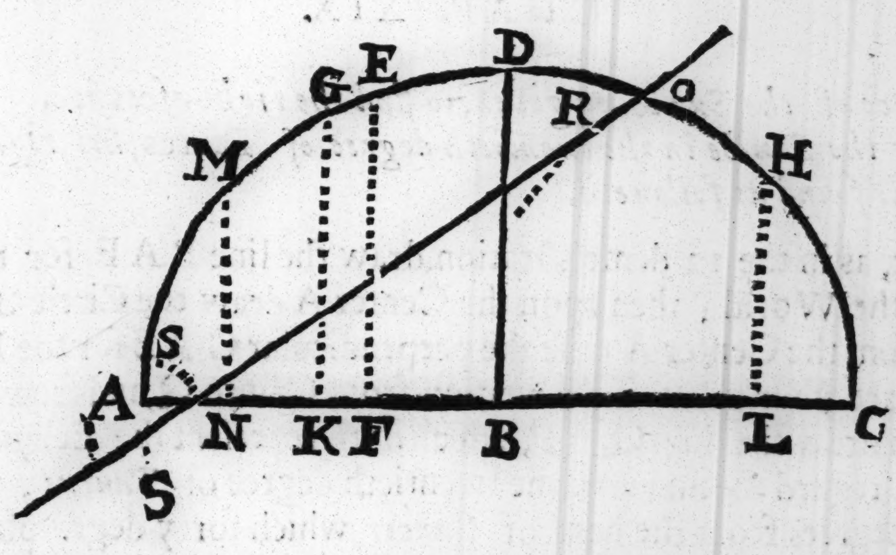
CHAP. XVIII.

The Latitude of the place, the Declination of the Sun, and the Altitude of the Sun being given, to find the Azimuth: By a new way differing from that in the former Chapter.

	deg.	min.		deg.	m.
The Suns declination is	20	00	its Compl.	38	30
The Latitude of the place is	51	30			
The Suns Altitude is	12	00		71	00
				Sum 116	

HAving found the sum and the difference of the Complement of the Suns altitude and Complement of the latitude as above is expressed, where you find the sum of them to be 116 deg. 30 min. and their difference 39 deg. 30 min.

These things being premised, with your Compasses being opened to 60 deg. of your line of Chords, describe the Semicircle A D C, and



upon the Center B erect the perpendicular B D, then first out of your line of Chords take 20 deg. the declination, and set that distance

distance from D to E, (if the Sun have South declination (as in this Example it hath) or from D to O, if the Sun have North declination) and draw the line E F parallel to D B.

Secondly, Take 116 deg. 30. m. the sum out of your line of Chords; and set it from C to G, and draw the line G K parallel to D B.

Thirdly, Take 39 deg. 30 min. the difference, out of your line of Chords, and set it from C to H, and draw the line H L parallel also to B D.

Fourthly, Take in your Compasses the distance from F to K, and setting one foot in A, with the other describe the arch S.

Fifthly, Take the distance from F to L, and setting one foot in C, with the other describe the arch R.

Sixthly, Lay a Ruler that it may only touch these two arches, S and R, and by it draw a line as S R, cutting the line A C in N.

Lastly, upon the point N, erect the perpendicular N M, then the distance A M measured upon your line of Chords, is the Azimuth from the South part of the Meridian, which in this example will be found to be 34 deg. M C the Azimuth from the North 146 deg. and M D the Azimuth from the East or West 56 deg.

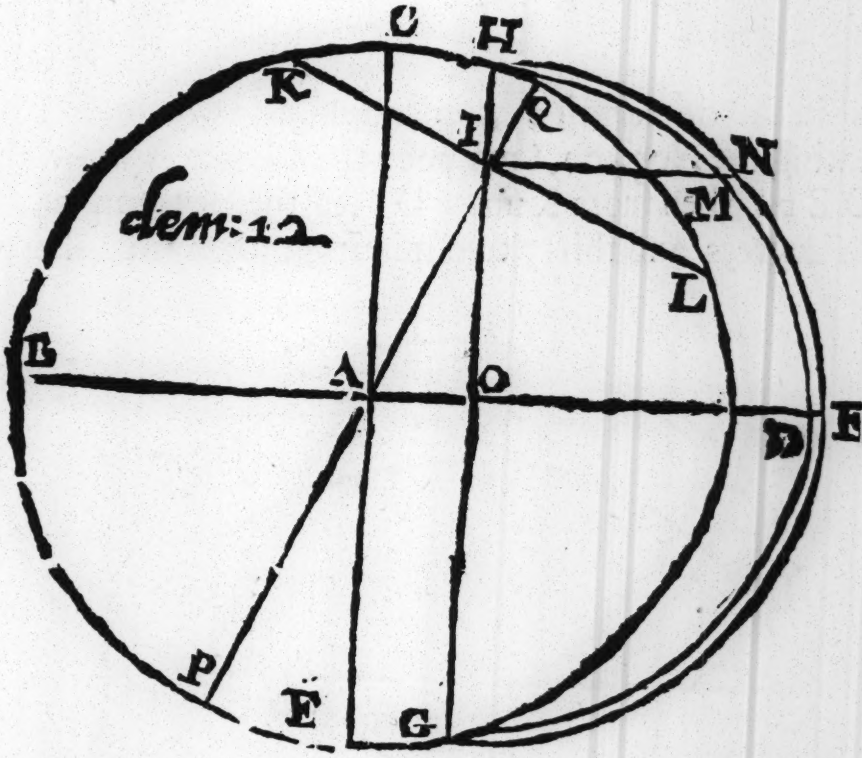
CHAP. XIX.

The place of the Sun being given, to find the right ascension.
Suppose the Sun be in the twentieth degree of Taurus, *his right ascension is found as followeth.*

FIrst, as in the 12 demonstration, draw the line B A F for the Pole of the World; then upon the Center A draw the Circle B C D E, then from the Center A raise the perpendicular C A E for the Equator, then place your greatest declination from C unto Q, and from E unto P, then draw the line Q A P, which doth represent the Ecliptick line, then in regard the Sun is in the twentieth degree of *Taurus*, which is forty degrees from the head of *Cancer*, which forty degr. place from Q unto L and unto K, then draw the line K L, cutting the Ecliptick in I; then from the point I draw the line H I parallel unto C A E, cutting the Pole of the World in O, then set one foot of your Compasses

in

in O, and extend the other unto G, with which diſtance draw the Semicircle H D G, then opening your Compaſſes unto the Radius of the Scale, and upon the Center O likewiſe draw the Circle H N F G, then



draw the line I M parallel unto A O D, cutting the Semicircle H M D G in M, then lay your Scale from the Center O unto the point M, and draw the line N M, cutting the Concentrick Circle in N ſo ſhall the diſtance N F, be the right aſcenſion, which is here found to be two and forty degrees, ſeven and twenty minutes.

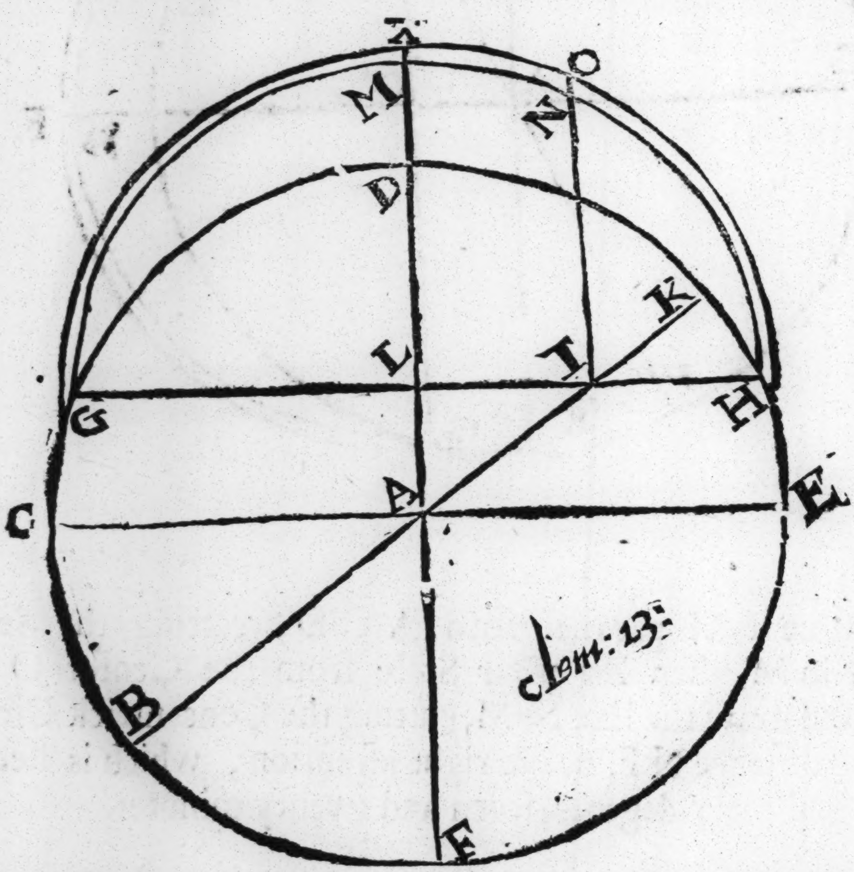
CHAP.

CHAP. XX.

The elevation of the Pole, and declination of the Sun given, to find the difference of the ascensions.

The Poles elevation is 51 degrees, 32 minutes, the declination of the Sun is 21 degrees.

FIrst, as in the thirteenth demonstration, draw the line B A K, representing the Horizon, then upon the Center A draw the Circle B C D E F, then from K unto D set the elevation of the Pole, which is 51 degrees and thirty two minutes: then from the point D,



by the Center A, draw the line D A F, representing the Pole of the World, then from B unto C set the Complement of the Poles elevation which is thirty eight degrees, and 28 minutes: then from C by the Center A draw the line C A E, representing the Equinoctial line; then

then from C unto G, and likewise from E unto H, for the declination of the Sun, which is 21 degrees, then from G unto H draw the parallel of the Suns declination, cutting the Pole of the World in L, and the Horizon in I, then set one foot of your Compasses in the point L, and extend the other unto G, then with that distance of your Compasses draw the Semicircle G M N H, then opening your Compasses unto the Radius of your Scale, upon the same Center draw the Concentrick Circle G X O H, then from I, where the declination of the Sun doth cut the Horizon, draw the line I N parallel unto the Pole of the World A M, cutting the Circle G M H in N, then lay your Ruler from the point I unto the point N, and so draw the line N O, cutting the Concentrick Circle G X O H in O, so shall the distance of O and X be the difference of the ascensions, which is here found to be eight and twenty degrees, and four and fifty minutes.

CHAP. XXI.

The right ascension of the Sun or of a Star being given, together with the difference of their ascension, to find the oblique ascension or descension.

The Sun is in the fourth degree of Sagitarius, *his right ascension is* 242 *degrees, or* 16 *hours* 8 *minutes, the difference of ascension is* 1 *hour* 53 *minutes or* 28 *degrees,* 28 *minutes, the oblique ascension or descension is required.*

THe right ascension of any point of the Heavens being known, the difference of the ascension is either to be added thereunto, or else to be substracted from it, according as the Star is situate in the Northern or Southern Signs: As for example, if the Sun be in any of these six signs, *Aries*, *Taurus*, *Gemini*, *Cancer*, *Leo*, or *Virgo*, then the difference of the ascensions is to be substracted from the right ascension, and the remainer is the oblique ascension. Suppose therefore the Sun to be in the fourth degree of *Gemini*, where the right ascension is found to be four hours, and 8 minutes, or 62 degrees, and the difference of ascension where the Pole is elevated 51 degrees, is found to be one hour 53 minutes, otherwise 28 degrees 50

I minutes,

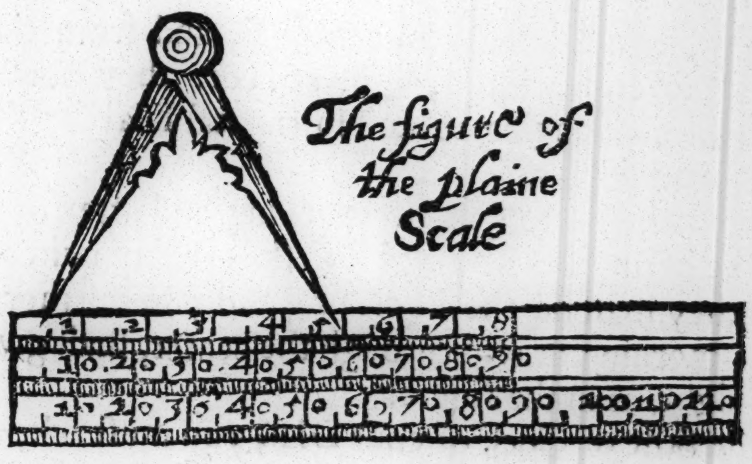
minutes, which being taken from the right aſcenſion, leaves two hours and 16 minutes, or 33 degrees and 42 minutes, which is the oblique aſcenſion of the Sun in the fourth degree of *Gemini*. But if the Sun be upon the South ſide of the Equinoctial, either in *Libra*, *Scorpio*, *Sagitarius*, *Capricornus*, *Aquarius*, or *Piſces*, then the difference of the aſcenſion is to be added unto the right aſcenſion, and the Products will be the oblique aſcenſion. Suppoſe the fourth degree of *Sagitarius* is given, for which ſign and degree the oblique aſcenſion of the Sun is deſired, his right aſcenſion being then found to be 242 degrees, or 16 hours 8 min. the difference of the aſcenſions is one hour 53 min. or 28 degrees 18 minutes: which being added unto the right aſcenſion, makes 18 hours one minute; or in degrees 270 degrees and 18 minutes, which is the oblique aſcenſion of the Sun when he is in the fourth degree of *Sagitarius*. And if you would find the oblique deſcenſion, you muſt add the difference of the aſcenſions unto the right aſcenſion, when the Sun is in theſe ſix Signs, *Aries*, *Taurus*, *Gemini*, *Cancer*, *Leo*, *Virgo*: and contrariwiſe, when the Sun is in the other ſix Signs, you muſt ſubſtract the difference from the right aſcenſion, and you ſhall have the oblique deſcenſion of the Sun or any Star, whoſe right aſcenſion and difference of aſcenſions is known. But it is to be underſtood, that this manner of operation doth ſerve no longer than you are upon the North ſide of the Equinoctial. For if the South Pole be elevated, the work is contrary: for ſo long as the Sun is in any of the Northern Signs, the difference of the aſcenſions is to be added unto the right aſcenſion, to find the oblique aſcention; and contrariwiſe, ſubſtracted to find the oblique deſcenſion. Likewiſe if the Sun or Star be in the Southern Signs then is the difference of aſcenſions ſubſtracted from the right aſcenſion to find the oblique aſcenſion, and added to find the oblique deſcenſion.

The End of the Second Book.

THE SEA-MANS GLASS.

The Third Book.

Shewing how by the Plain Scale to delineate Hour-lines upon all kind of Upright Plains, either Direct or Declining, in any Latitude.



CHAP. I.

How to draw Hour-lines upon an Horizontal Plain in any Latitude.

With the Radius of your line of Chords, upon E as a Center, describe the Circle A B C D, and cross it with the Diameters A B and C D. This done, out of the line of Chords take the Complement of the Latitude of your place)which we here suppose to be *London*, whose Latitude is 51 deg.

30 min. and its complement 38 deg. 30 min.) which set from B to G, from G to N, and from D to M; then lay a Ruler from A to G, and it will cut the line C D in H, and from A to N it will cut C D in O, and from A to M it will cut the same line in F.

This done, upon O (as a center) place one foot of your Compasses, and extend the other foot to F, and with this distance describe an arch of a circle, which (if the rest of your work be true) will fall just in the points A and B, and so constitute the arch A F B representing the Equinoctial Circle, and so we shall hereafter call it.

Having drawn the Equinoctial A F B, divide the Semicircle A D B into 12 equal parts in the points ✱ ✱ ✱, &c. Then laying a Ruler to the center E, and every one of these marks ✱ ✱ ✱, &c. it will divide the Equinoctial circle into twelve unequal parts in the points ● ● ● ● &c.

Again, Lay a Ruler to H, and every of these unequal parts ● ● ● ● &c. it will cut the Semicircle A D B in the points 7, 8, 9, 10, 11, 12, 1, 2, 3, 4, 5, and 6.

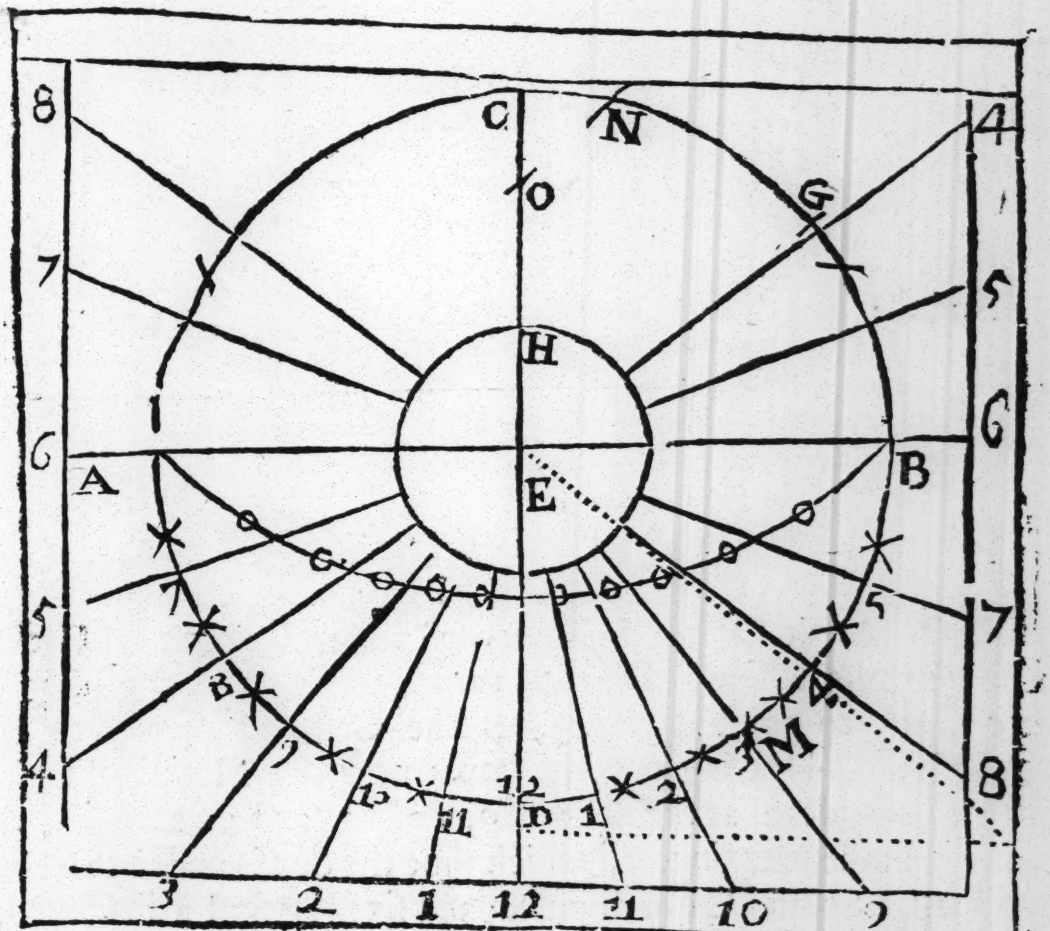
Lastly, If you lay a Ruler on the center E, and from thence draw right lines to the several points 7, 8, 9, 10, &c. they shall be 12 of the true hour-lines belonging to an Horizontal Dial for the Latitude of 51 degrees, 30 minutes.

But for the hours before 6 in the morning and after 6 at night, do thus; draw the hour-lines of 4 and 5 in the evening quite through the center E, and they shall be the hours of 4 and 5 in the morning; also 7 and 8 in the morning drawn through the center, shall give the hours of 7 and 8 at night, as in the figure.

Now for the Stile or Cock of your Dial, you must take out of your line of Chords the degrees of your Latitude, *viz.* 51. degrees, 30 minutes, and set it from D to S, and draw the line D S, so shall the triangle D E S be the just pattern for the Cock of your Dial, which being made of Brass, or the like, and set exactly upright upon the hour-line of 12, your Dial is wholly finished.

An

An Horizontal Dial for the Latitude of 51 deg. 30 minutes.



CHAP. II.

Concerning direct South Dials.

A Direct South Dial is no other than an Horizontal Dial, the making whereof is before described, the difference consisting only in the numbring of the hours; and in the placing of it, the one being to be fixed on a Post, or the like, and the other to be fixed to a Wall which exactly beholds the South, I say here is no other difference: For,

An Horizontal Dial for the Latitude of	degrees	Will be a direct South Dial in the Latitude of	degrees
	10		80
	20		70
	30		60
	40		50
	50		40
	60		30
	70		20
	80		10

And the like in any other Latitude, as 15, 16, 33, &c.

CHAP. III.

Of direct North Dials.

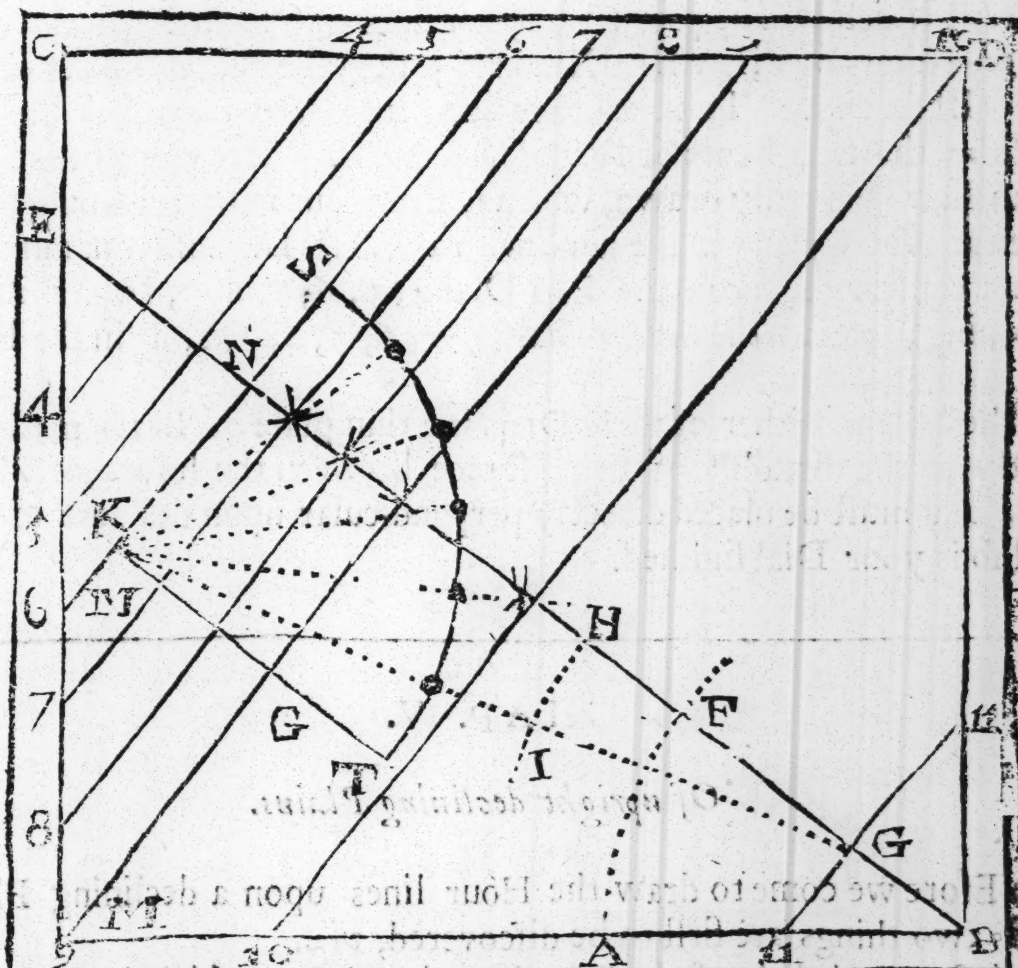
A Direct North Dial is the same with a Direct South Dial; for, if you take a South Dial and turn it upside down, causing the Stile or Cock to point upwards, as the Cock of the South doth downwards, and leaving out the hours near the Meridian, in these Northern Latitudes: as the hour of 9, 10, 11, and 12 at night, and 1, 2, and 3 in the morning, all which time the Sun is under the Horizon. I say a South Dial so disposed, and fixed against a direct North Wall, shall give you the true hour of the day.

CHAP. IV.

How to draw the hour-lines on a direct East or West Plain.

A Direct East or West Plain, is such a Plain as directly lieth open to the East or West points of the heavens; as the North and South Plains do to the North and South points. To make such a Dial, Upon the Plain C B D M (in some convenient places thereof towards the lower part) assume the point B, then with the Radius of your line of Chords upon B as a Center, describe the obscure arch A F, then from

from your Chord take the Complement of the latitude of your place, 38 degrees, 30 minutes, and ſet it from A to F, then from B through F draw the line B E, repreſenting the Equinoctial Circle, which in theſe plains, (as alſo in a Polar Dial) becomes a ſtreight line. In this line E B aſſume two points, one towards one end, and the other to-



wards the other end of the ſame line; as the points G and N, one for the hour of VI, as N; the other for the hour of XI, as G: through theſe two points N and G, draw two right lines quite through your Plain, perpendicular to the Equinoctial line B E, as in the figure, which two lines ſhall repreſent Eleven and ſix of the Clock.

This

This done, upon the point G, with the Radius of your Chord deſcribe an occult arch of a circle H I, and ſet thereon 15 degrees from H to I, then from G through I draw the line G K, cutting N M in K; on K, as a center, with the Radius of your Chord deſcribe the quadrant K S T, which divide into 6 equal parts in the points ●●●●, through which points and K, draw the lines K●, K●, &c. cutting the Equinoctial E B in **** &c. Through theſe points *** &c draw right lines quite through your plain perpendicular to the equinoctial, which will be parallel to your lines of VI and XI, and will be the true hours of VII, VIII, IX and X; then the like diſtances of VII and VIII ſet above VI on the other ſide, and drawn parallel thereto, ſhall be the true hours of IV and V; and thus have you all the hours of an Eaſt Dial truly drawn, which is from four in the Morning till eleven at Noon; and is the ſame with a Weſt Dial only naming the hours contrary: for in the Eaſt Dial 4, 5, 6, 7, 8, 9, 10, 11 in the Morning, are in the Weſt Dial 8, 7, 6, 5, 4, 3, 2, 1 in the Evening.

The Stile of either of theſe Dials is a thin plate of Braſs made directly of the breadth of the diſtance between the hours of VI and IX, and muſt be placed directly perpendicular upon the line of VI, and ſo is your Dial finiſhed.

CHAP. V.

Of upright declining Plains.

BEfore we come to draw the Hour lines upon a declining Plain, two things are firſt to be diſcovered, *viz.*

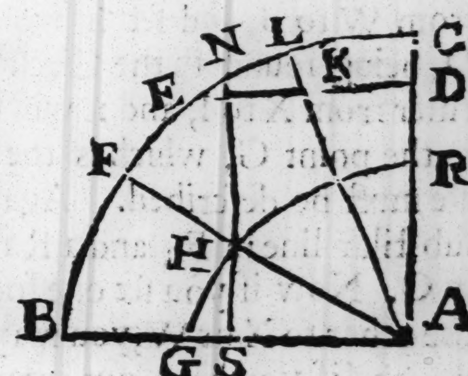
Firſt, *The height of the Pole above the Plain*, which is the height of the Cock or Stile.

Secondly, *The deflexion* or diſtance of the ſubſtile from the Meridian or line of twelve of the Clock.

1. *To find the heighth of the Pole above a declining Plain.*

With the radius of your line of Chords, upon A, as a Center, describe the Quadrant A B C, then your latitude being 51 deg. 30 min. take it out of your line of Chords, and set it from B to E; and draw the line E D parallel to A B, cutting the line A C in D, then with the distance D E, on the Center A, describe the Quadrant G H R. Then supposing your Plain to decline 30 deg. set 30 deg. from B to F, in the Quadrant B E C, and draw the line F A cutting the Quadrant G H R in H, through which point H, draw the line S H N parallel to C A, and cutting the Quadrant B E C in N, so shall the arch C N be the height of the Pole above the Plain, and in this Example contains 32 deg. 37 min.

2. *To find the deflexion, or the distance of the Substile from the Meridian.*



Out of this figure take the distance H S, and set it in the line D E, from D to K; through which point K, draw the line A K L, cutting the Quadrant B C in L; so shall the arch C L be the distance of the Substile from the Meridian: and in this Example will be found to be 21 degrees 42 minutes.

CHAP. VI.

How to draw the Hour-lines upon an upright Plain declining from the Meridian towards the East or West.

WE will hear take for Example a South erect Plain, declining Eastward 30 deg.

Having (by the fifth Chapter of this Book) found the Deflexion of ſuch a Plain to be 21 deg. 42 min. And the height of the Stile (by the ſame Chapter) to be 32 deg. 37 min. we may proceed to draw the Dial in manner following.

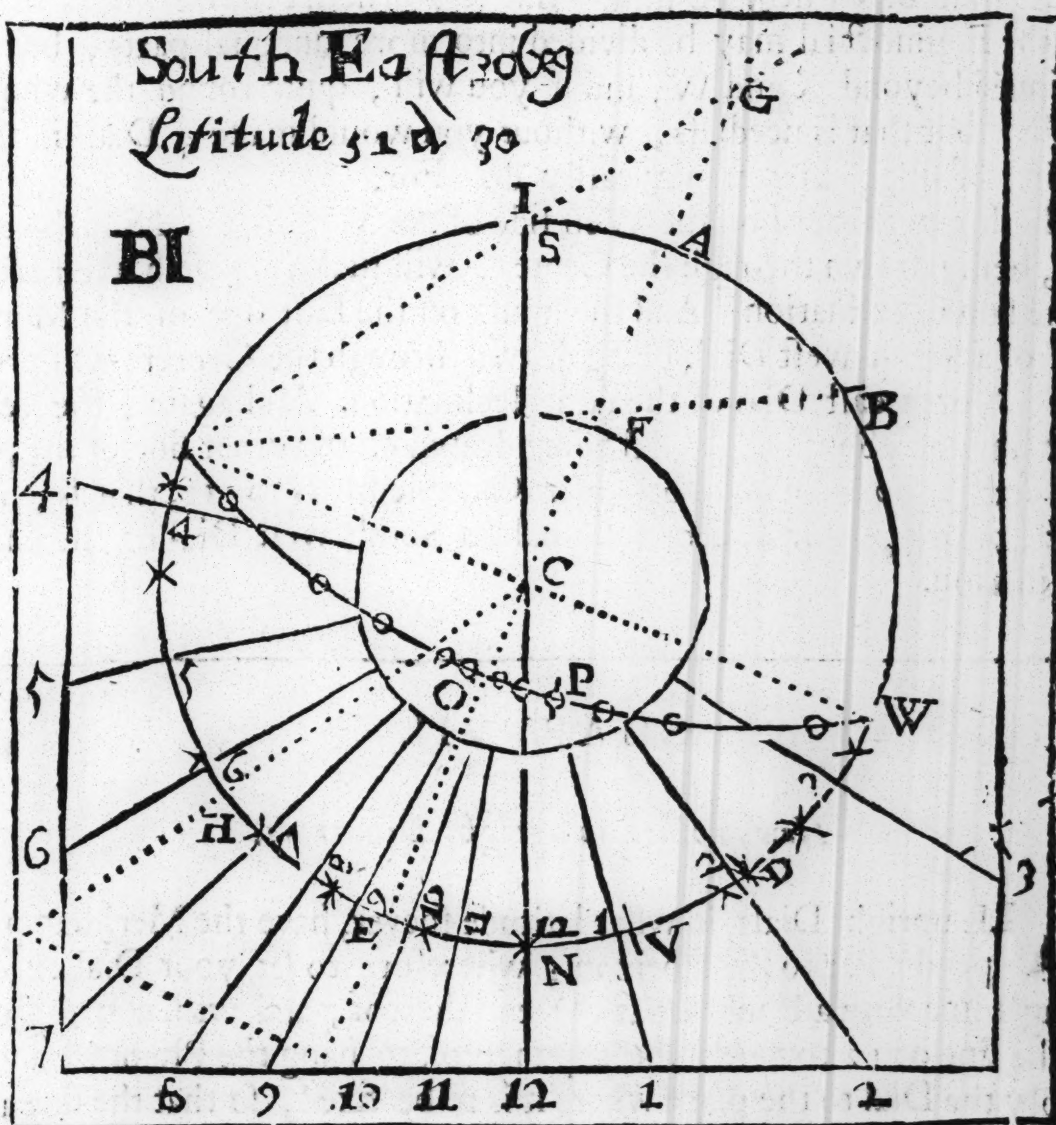
With the Radius of your line of Chords, on the Center C, deſcribe the Circle X N S W; and in it draw S N through the center C, for the Meridian, or line of 12. Then the deflexion being found to be 21 deg. 42 min. ſet that from N to E, and draw the line E C through the center to G; this line repreſenteth the Subſtilar line of your Dial, upon which line the Stile or Cock muſt ſtand. Alſo out from your line of Chords take 32 deg. 37 min. the height of the Stile, and ſet that diſtance from E to H, and draw the line C H for the Stile of your Dial; ſo ſhall the Triangle E C H be the true pattern for the Cock of your Dial.

The Subſtilar line E G being drawn, draw the line X W through the center C, and perpendicular to E G. This done, take the diſtance E H, (which is equal to the Stiles height) and ſet that diſtance from A to B, and from W to D. Likewiſe take the diſtance from W to B, and ſet it from B to I. Theſe three points I B, and D, being found in the Circumference of the Circle X N S W, lay a ruler from X to I, and it will cut the ſubſtilar line E C being extended in the point G, which is the Center upon which the Equinoctial Circle muſt be deſcribed. Again, a Ruler laid from X to B, will cut the ſubſtilar line in F; and a Ruler laid from X to D, will cut the ſubſtilar in O. Now if you ſet one foot of your Compaſſes in G, and extend the other to X or W, you may deſcribe the Equinoctial Circle X O W, which (if you have not erred in your former Work) will paſs exactly through the point O in the ſubſtilar line before found. In the next place, if you lay a Ruler from F to N, it will cut the Equinoctial Circle in P; and a Ruler laid from C to P, will cut the Dial Circle in V.

Theſe things being performed, the next thing is to draw the hour lines, which will be eaſily effected, if you obſerve the former directions.

Firſt, From the point V laſt found, begin to divide your hour Circle into 24 equal parts (or only one half of it into 12 parts) which you may do by taking 15 deg. out of your line of Chords, and

ſet that diſtance on both ſides of V at the marks ✱✱✱ &c. ſo many times as the Plain is capable of hours.



This done, If you lay a Ruler on the Center C, and every of theſe points ✱✱✱✱ &c. you ſhall divide the equinoctial Circle into 12 unequal parts in the points ●●●● &c. Now a Ruler laid from F to every of theſe unequal points ●●●● &c. will divide the hour-circle into 12 other unequal parts, marked with 4. 5. 6. 7. 8. 9. 10. 11. 12. 1. on the one ſide of V, and with 2, 3. on the other ſide of V.

Lastly, A Ruler laid from C to the several points 4. 5. 6. 7. 8. 9. 10. 11. 12. 1. 2. 3. and lines drawn by the side thereof, they shall be the true hour lines belonging to such a declining Plain of 30 deg. in the Latitude of 51 deg. 30 min. But if you desire more hours than 12, the Equinoctial may be divided into more unequal parts, being continued beyond X and W, and if you will, quite round the whole Circle, but that is needless, without you would make 4 Dials in the making of one, as you may easily do. For,

The hours that are on the West side of the Meridian of a South-east Dial, being drawn through the Center, will make a North-west Dial of the same declination. And the hours on the East side of the Meridian of a South-west Dial, being drawn through the Center, will produce a North-east Dial of the same declination. And again, the real hour lines of a South-east Dial being drawn on the other side of the paper, and the hours named by their Complements to 12, that is, 10 for 2, 9 for 3, 8 for 4, &c. will make a South-west Dial of the same declination.

CHAP. VII.

How to place an upright Dial truly.

ALL upright Dials, in what latitude soever, have the Meridian perpendicular to the Horizon; wherefore to set your Dial exact, hang a line with a Plummet at the end thereof, and with a nail fixed in the line of 12 towards the top thereof, to hang the Plummet upon, apply the Dial to the place where it is to be fixed, so that the line and Plummet may hang just down upon the line of 12, neither inclining on one side or the other; the Dial thus fixed, if the delination were truly taken, and the Dial rightly made by the former directions, shall at all times (the Sun shining upon it) give you the true hour of the day.

CHAP.

CHAP. VIII.

How to insert the half and quarters of hours in all Dials.

THe halfs and quarters of hours are drawn in all Plains by the same rules, and the like reason, that the hours are inserted. Therefore take notice that if you would insert the half hours into any Dial, you must divide your Equinoctial Circle into 24 equal parts instead of 12, and if you would insert the quarters, then you must divide it into 48 parts, and then proceed in all respects as you did for the whole hours.

CHAP. IX.

How to find the Declination of any upright Wall.

THe declination of a Plain is an arch of the Horizon comprehended between the Pole of the Plains Horizontal line, and the Meridian of the place.

To find this declination, two observations must be made, the Sun shining, and both at one instant of time (as near as may be.) The first is the Horizontal distance of the Sun from the Pole of the Plain. The second is the Suns Altitude.

First, to find the Horizontal distance. Apply the side of a Quadrant to your plain, holding it (as near as may be) horizontal, that is to say, level; then holding up a thred and plummet, which must hang at full liberty, so that the shadow of the thred may pass directly through the center of the Quadrant, then diligently note through the degree of the Quadrant the shadow passed, and count those degrees from the side of your Quadrant which is perpendicular to the Plain, for those degrees are the Horizontal distance.

Secondly, At the same instant, take the Suns altitude, these two being heedfully taken, will help you to the Plains declination by the rules following.

By

By the 17 or 18 Chapters of the second Book find the Suns Azimuth. Then observe whether the Sun be between the Pole of the Plains Horizontal line and the North or South points, or not.

If the Sun be between them, add the Azimuth and Horizontal distance together, and the sum of them is the declination of the Plain.

If the Sun be not between them, substract the lesser of them from the greater, and the difference shall be the declination of the Plain. These rules shew you the quantity of your Plains declination. But,

CHAP. X.

Shewing how to know whether your Plain decline from the Meridian towards either the East or West.

YOu must take notice in your observation, that if the Meridian point fall between the Azimuth and the Pole of the Plains Horizontal line, then doth the plain decline to to the Coast contrary to that wherein the Sun is; that is to say, if the Sun be to the Eastward of the Meridian, the plain declines to the Westward: But if the Meridian point be not between the forementioned distance and the Pole of the Plain, then doth the Plain decline to the same Coast in which the Sun was in the time of observation.

CHAP. XI.

Concerning Polar Dials.

A Polar Dial is made in all respects as an East or West Dial is made, only the line of 6 a Clock in the East or West Dial, is 12 a Clock in the Polar Dial, the hour of 7 is 1, 8 of is 2, of 9 is 3, of 10 is 4, and of 11 is 5. Also the hour of 5 in the East or West Dial, is 11 in the Polar, of 4 is 10, of 3 is 9, of 2, 8, 1 is 7, &c. The Cock of this Dial is a plate of Iron or Brass made of the breadth

be-

between 12 and 3 a clock, and ſet perpendicular upon the line of 12, as in the Eaſt or Weſt Dial it is upon the line of 6. In theſe Dials the Equinoctial line is to lie parallel to the Horizon, and not to be elevated according to the complement of the latitude of the place, as in the Eaſt or Weſt Dial it is.

CHAP. XII.

Concerning Equinoctial Dials.

AN Equinoctial Dial is of all other Dials the moſt eaſie to make, for if you deſcribe a Circle, and divide it into 24 equal parts, and draw lines from the Center through every one of thoſe equal parts, the lines ſo drawn ſhall be the true hour lines.

For the Stile of theſe Dials, it is no other but a ſtreight Wyre of any length, ſet perpendicular in the Center of the Circle, whoſe ſhadow ſhall give the true hour of the day.

CHAP. XIII.

Of ſuch plains as decline very far from the Eaſt or Weſt towards the Meridian, as 75, 80 or 85 deg. above which Plains the Pole hath ſmall Elevation.

SUch Plains as decline above 60 degrees the hour lines will come very cloſe together, ſo that if they be not extended very far from the Center, there will be no ſenſible diſtance between hour and hour.

To remedy this inconvenience, there are ſeveral ways, I will inſtance only in one, which is familiar and eaſie, and that is this.

When you have drawn your Dial on a large ſheet of Paper, fix it on ſome large Table or ſmooth Floor of a Room, if the Dial you are to make be very large, as 5, 6, or 7 foot ſquare, then by the ſide of

of a long Ruler laid to the Center and every hour-line, as also to the Stile and Substile, draw lines to the full extent of the Table or Flower, and you shall find them to be of a competent largeness. Then according to the bigness of your Plain cut off the hours, Stile, and Substile, leaving the Center quite out, and your Work is finished.

CHAP. XIV.

Concerning Declining, Reclining, and Inclining Dials.

WE should now shew the manner of drawing hour-lines upon declining, reclining, and inclining Plains, of which there are several varieties, and many cautions, which in this place, and at this time would be too many to enumerate: but if this which hath been already delivered concerning Upright decliners shall be kindly accepted, it shall animate me to do the like for all other Plains whatsoever.

AN

AN

APPENDIX,

Containing the Use of

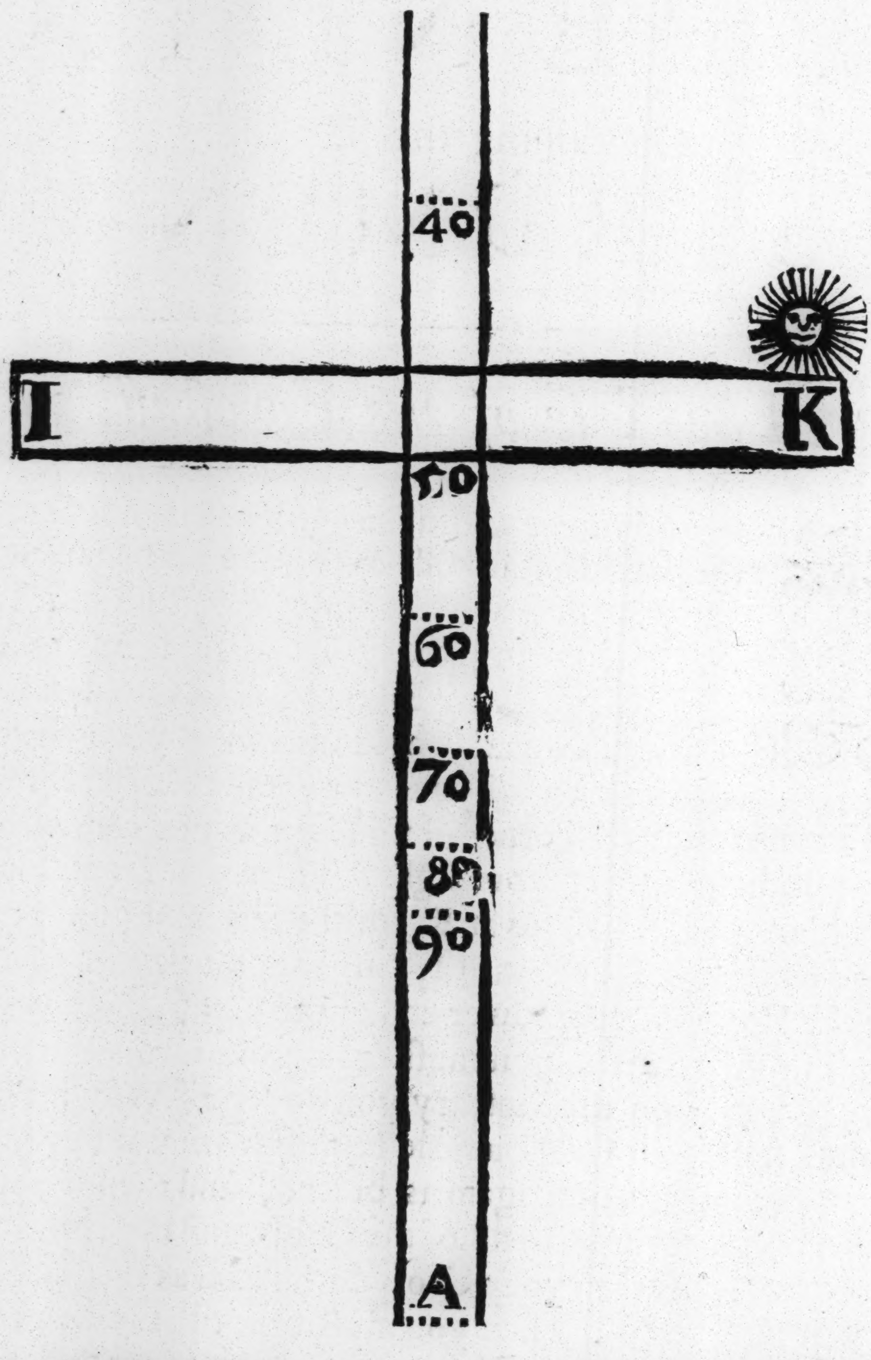
INSTRUMENTS.

The Use of the Foreſtaff.

VEry common and ordinary it is for men at Sea, to take the Meridian altitude of the Sun and Stars with this Inſtrument, and thereby they find the Latitude that they are in; the which to perform, take notice of theſe following Precepts and Examples.

Firſt, You muſt hold the end of your Staff, as A, to the corner of your eye; and there let it reſt upon your Eye-bone, as near the corner of your eye as you can with convenience, ſo it doth not hinder your ſight: Then you are to look up to the upper end of your Croſs, as at K, for the Sun, and you are to look at the lower end of the Croſs, as at I, for the Horizon: but if you cannot ſee the Horizon at the lower end of the Croſs, but you do ſee all Skie and no Water, then you muſt draw your Croſs a little nearer to your eye; but if on the contrary you do ſee all Water and Skie, then you muſt ſlide your Croſs a little farther from your eye, and then you muſt make obſervation again as before, and then if you ſee the center of the Sun at the upper end of the Croſs, and the Horizon at the lower end of the Croſs, then your Croſs doth ſtand as it ought, and that is all that you have to do: Then you muſt wait till the Sun be on the Meridian, and you muſt make Obſervation again as oft as your judgment ſhall think fit, and as you find the Sun to riſe, you muſt draw your Croſs a little nearer to your eye; but if the Sun be fallen, then you

The Figure of the Foreſtaff.



will not ſee the Horizon, for the Water will hide it from you, and in ſuch a caſe as this you muſt not alter your Croſs, but look on that line on your Staff that your Croſs doth belong to, and thoſe degrees and minutes

nutes that the Cross doth stand at, is the Suns Meridian altitude.

Thus I have shewed you how to take an Observation by the *Fore-staff*: The next thing that followeth in course, will be to shew you how to work your Observation; which to do, take notice of these following Rules.

To work your Observation.

If the Sun hath North Declination, and be on the Meridian to the Southwards of you, then you must substract the Suns Declination from your Meridian altitude, and the remainer is the height of the Equinoctial, or the complement of the Latitude North.

But if the Sun hath South Declination, you must add the Suns Declination to the Meridian altitude, and the Sum is the height of the Equator, or the complement of the Latitude North.

If the Sun hath North Declination, and be on the Meridian to the Northwards, then add the Suns Declination to your Meridian altitude, and the sum is the height of the Equator, or the complement of the Latitude South, if the said sum doth not exceed 90 deg. but if it doth exceed 90 deg. you must substract 90 deg. from the said sum, and the remainer is your Latitude North.

If the Sun hath South Declination, and be to the Northwards at Noon, you must then substract the Suns Declination from his Meridian altitude, and the remainer is the complement of your latitude South.

When the Sun hath no Declination, then the Meridian altitude is the complement of the latitude.

If the Sun be in the Zenith, and if at the same time the Sun hath no Declination, then you are under the Equinoctial.

But if the Sun hath North Declination, and in the Zenith, then look how many deg. and min. the Declination is, and that is the latitude that you be in North.

But if your Declination be South, then you are so much in South latitude.

If you observe the Sun or a Star upon the Meridian beneath the Pole, then add your Meridian altitude to the complement of the Sun or Stars Declination, and the sum is the height of the Pole.

Rules for Observation in North Latitude.

Admit I am at Sea, and observe the Suns Meridian altitude to be

42 deg. 20 min. and at the ſame time the Suns Declination is 10 deg. 10 min. North, I demand the Latitude that I am in

The Meridian altitude	42 deg.	20 min.
The Declination North Subſt.	10	10
The complement of the Latitude	32	10
	90	00
The Latitude that I am in	57	50 *North.*

Admit a Ship at Sea the 22 of *May*, *Anno* 1668, and I find the Suns Meridian altitude to be 65 deg. 10 m. I demand the Latitude.

The Meridian altitude	65 deg.	10 min.
The Declination North Subſt.	22	15
The complement of the Latitude	42	55
	90	00
The Latitude that I am in	47	5

Admit a Ship at Sea the 27 day of *Nov.* *Anno* 1687. and I find the Suns Meridian altitude to be 26 deg. 30 min. I demand the Latitude that I am in.

The Meridian altitude	26 deg.	30 min.
The Declination South Add	22	44
The complement of the Latitude	49	14
	90	00
The Latitude that I am in	40	46

Admit a Ship at Sea the 25 day of *April*, *An.* 1665. and I find the Suns Meridian altitude by obſervation to be 58 deg. 45 min. I demand the Latitude that I am in.

The Meridian altitude	58 deg.	45 min.
The Declination North Subſt.	16	31
The complement of the Latitude	42	14
	90	00
The Latitude I am in	47	46

Admit a Ship at Sea the 12 day of *June*, *An.* 1669. and I find the Suns Meridian altitude by obſervation to be 80 deg. 35 min. *North*, I demand the Latitude that I am in.

The

The Meridian altitude		N. 80 deg.	35 min.	
The declination North	Add	23	31	
		104	06	
		90	00	
The Latitude that I am in		14	60	North.

Admit a Ship at Sea the 22 of *August*, *Anno* 1771. and the Suns Meridian altitude was observed to be 85 deg. 15 min. *North*, I demand the Latitude that I am in.

The Meridian altitude		85 deg.	15 min.	
The Declination North	Add	08	17	
		93	32	
		90	00	
The Latitude that I am in		03	32	North.

Admit a Ship at Sea the 20 of *June Anno* 1657. and the Suns altitude was 66 deg. 45 min. *North*, I demand the Latitude that the Ship is in.

The Meridian altitude		66 deg.	45 min.
The Declination North	Add	23	15 min.
		90	00
		90	00
The Ship is under the Equinoctial		00	00

Rules for observing the Stars.

Admit I am at Sea, and observe the *Bulls Eye* upon the Meridian, and I find his Meridian altitude to be 50 deg. 30 min. I demand the Latitude that I am in.

The Declination of this Star is		15 deg.	46 min.	*North*.
The Meridian altitude		50	30	
The Declination North,	Subst.	15	46	
Complement of the Latitude		34	44	
		90	00	
The Latitude I am in		55	16	*North*.

Admit I am at Sea, and I observe the bright Star in the *Great Dogs* Mouth, and I find his Meridian altitude to be 35 deg. 45 min. I demand the Latitude that I am in.

The

The Declination of this Star is	16 deg.	15 min.	*South*
The Meridian altitude	35	45	
The Declination South Add	16	15	
The heighth of the Equator	52	00	
	90	00	
The Latitude that I am in	38	00	

Rules for Observation in South Latitude.

Admit a Ship at Sea the 10 day of *May*, *Anno* 1674. and I find the Suns Meridian altitude by observation to be 62 deg. 00 m. *North.* I demand the Latitude that the Ship is in.

The Meridian altitude North	62 deg.	00 min.	
The Declination North Add	20	08	
The complement of the Latitude	82	08	
	90	00	
The Latitude that the Ship is in	07	52	South.

Admit a Ship at Sea the 15 day of *January*, *Anno* 1692. and in Longitude 150 deg. *East*, and I find the Meridian altitude by observation to be 58 deg. 45 min. *North.* I demand the Latitude that the Ship is in.

The Declination in the Meridian of *London* for the 15 of *January* as abovesaid, is 18. deg. 57. min. the daily difference in Declination at this time is 15 min. therefore if you look in the Table of Proportion, you will find the proportional minutes to be 6 min. which you must add to the declination in the Meridian of *London*, and the sum will be the true declination for the Longitude of 150 deg. East, which is 19 deg. 03 min.

The Meridian altitude North,	58 deg.	45 min.	
The Declination South, Subst.	19	03	
The complement of the Latitude	39	42	
	90	00	
The Latitude that the Ship is in	50	18	South

Admit a Ship at Sea the 12 day of *July*, *Anno* 1673. and I find the Suns Meridian altitude to be 66 deg. 52 min. *North.* I demand the Latitude.

The

The Meridian altitude North,	66 deg.	62 min.
The Delination North, Add	20	14
The complement of the Latitude	87	06
	90	00
The Latitude required South	02	54

Admit a Ship at Sea, the Suns declination being 15 deg. 30 min. *South*, and the Suns Meridian altitude 80 deg 45 min. *South*, I demand the Latitude that the Ship is in.

Answer, 06 deg. 15. m. *South.*

Admit a Ship at Sea, the Suns delcination being 11 deg. 14 min. *South*, and the Suns Meridian altitude 79 deg. 38 min. *South*, I demand the Latitude.

Answer, The Ship is in Latitude 00 deg. 52 min.

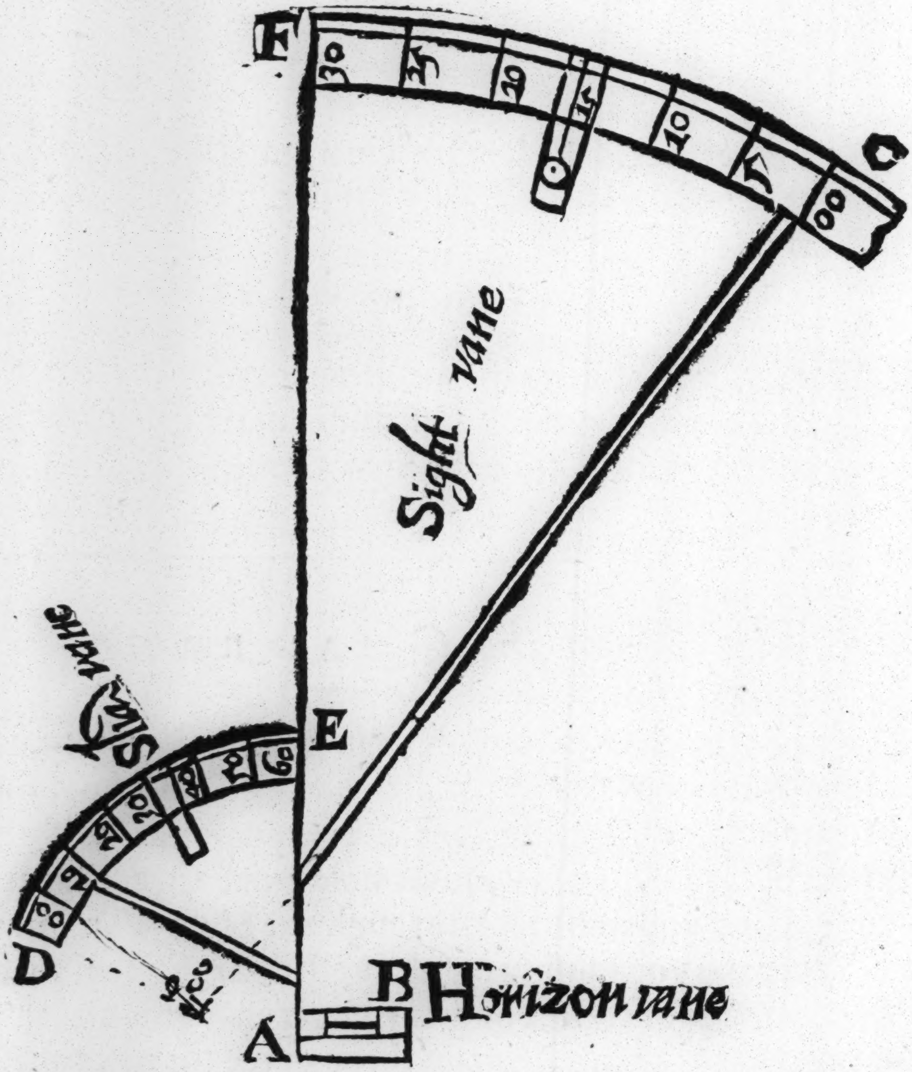
¶ *Note*, If you observe by the lower part of the Sun, you must add 16 min. for the Suns semidiameter, and the sum will be the true altitude of the Suns Center.

The Use of the QUADRANT.

WHen you take the height of the Sun with a Quadrant, you must stand with your back to the Sun, and you must hold the handle of your Quadrant, as C, in your hand, and you must hold the Sight-Vane to your Eye, and then you must hold your Quadrant as upright as you can: Then you must look through the Sight-Vane upon your Horizon-Vane, and you must bring the upper part of the shade to lie upon the upper edge of the slit on your Horizon-Vane; and at the same time you must look for the Horizon through the slit of your Horizon-Vane: But if you cannot see the Horizon, but you do see all Skie and no Water, then draw yout Sight-Vane a little lower down towards C: But if you see all Water and no Skie, then put your Sight-Vane a little higher up towards F, and when you have done so, observe again, and then if you see the shade lie upon the upper part of the slit on the Horizon

rizon Vane, and you at the ſame time to ſee the Horizon through the Sight Vane, then that is all that you have to do: Then you muſt wait till the Sun be on the Meridian, and you muſt tend the Sun, and make obſervation as often as your judgment ſhall think fit: But if the Sun

The Figure of the Quadrant.



be fallen, then when you go to obſerve again, you will not ſee the Horizon, for the Water will hide it from you, then you muſt not alter your Vanes; but you muſt let them ſtand as they were, and leave off obſerving: Then look what degrees do ſtand by the upper edge

edge of your ſhade Vane, which note, and look likewiſe what degrees ſtand againſt your ſight, by your ſight Vane; which add to the former degrees noted by the ſhade Vane, and their ſum is the diſtance from the Zenith to the upper edge of the Sun, to which ſum if you add 16 min. which is the Suns Semidameter, you will have the true diſtance of the Suns Center from the Zenith, or the complement of the Meridian altitude: for if you obſerve by the upper part of the ſhade, then it is the upper limb of the Sun that gives the ſhade: But if you obſerve by the lower part of the ſhade, then it is the lower limb of the Sun that gives the ſhade. Therefore, if you obſerve by the upper part of the ſhade, you muſt add 16 min. but if you obſerve by the under part of the ſhade, you muſt ſubſtract 16 min. to or from what your Inſtrument gives, and the ſum or difference is the true diſtance of the Suns center from the Zenith.

Thus I have ſhewed you how to take an Obſervation with the Quadrant, I come now to ſhew you how to work your Obſervation. The difference that there is in working of an Obſervation taken by the Foreſtaff and the Quadrant, is only this. By the Foreſtaff you do take the altitude, but by the Quadrant you do take the complement of the altitude, or the diſtance of the Sun from the Zenith, but the altitude is the diſtance of the Sun from the Horizon, therefore if you do ſubſtract the complement of the altitude from 90 deg. the remainer will be the altitude which you muſt uſe, as you were ſhewed in the uſe of the Foreſtaff.

But becauſe it is uſual to work Obſervations that are taken by the Quadrant, by the complement of the Suns Meridian altitude, I will therefore give you ſome general Rules, and afterwards ſome particular Examples, and then I ſhall proceed to what followeth

If the Sun hath North declination, and you in North Latitude, and the Sun upon the Meridian to the Southwards, then if you add the Suns declination to the Zenith diſtance, or complement of the Suns Meridian altitude, the ſum will be the Latitude that you are in.

But on the contrary, If the Sun hath South declination, you muſt ſubſtract the Suns declination from the Zeniths diſtance, and the remainer will be the Latitude that you are in.

If yoube in South Latitude, and the Sun to the Northwards of you, then if the Sun hath South declination, you muſt add the Suns declination

tion to the Zenith distance, and the sum will be the Latitude that you are in South.

But if the Sun hath North declination, you must substract the Suns declination from the Zenith distance, and the remainer will be the Latitude that you are in South.

¶ I might have been more large herein, giving you more general Rules: but if you understand those Rules that I have written for the use of the *Forestaff*, you cannot err in using your *Quadrant.*

Admit a Ship at Sea the 10 day of *April*, *Anno* 1668. and I find the upper limb of the Sun to be distant from the Zenith 34 degrees 47 minutes; the Sun being upon the Meridian, I demand the Latitude that I am in.

Rules for Observation in North Latitude.

		deg.	min.
Complement of Meridian altitude		34	47
The Suns Semidiameter	add	00	16
Distance of Suns center from Zenith		35	03
Declination North	add	11	55
Latitude that the Ship is in		46	58

A Ship at Sea the 14 of *August*, *Anno* 1672, and I find the Complement of the Suns Meridian altitude by observation to be 28 deg. 48 min. *South*, I demand the Latitude that the Ship is in.

		deg.	min.
Complement of Meridian altitude		28	48
Suns Semidiameter	add	00	16
Distance of Suns center from Zenith		29	04
Declination North	add	10	52
The Latitude that the Ship is in		39	56

Admit a Ship at Sea the 13 day of *Sept. Anno* 1674. and I find the Complement of the Suns Meridian altitude by observation to be 47 deg. 35 min. I demand the Latitude that I am in.

Com-

Complement of Meridian altitude	47 deg.	35 min.
Suns Semidiameter add	00	16
Distance of Suns center from Zenith	47	51
Declination South substract	00	13
Latitude that the Ship is in	47	38

Admit a Ship at Sea the 5 day of *November*, *Anno* 1665. and I find the Complement of the Suns Meridian altitude by observation to be 52 deg. 00 min. I demand the Latitude that the Ship is in.

Complement of Meridian altitude	52 deg.	00 min.
Suns Semidiameter add	00	16
Distance of Suns center from Zenith	02	16
Declination South substract	18	45
Latitude that the Ship is in	33	31

Admit a Ship at Sea the 27 of *May*, *Anno* 1692, and I find the Sun to be to the Northward of me; and I find the complement of his Meridian altitude by Observation to be 10 deg. 15 min. I demand the Latitude that the Ship is in.

Suns Declination North	22 deg.	49 m.
Complement of Meridian altitude	10	15
The Suns Semidiameter add	00	16
The true Zenith distance substract	10	31
Latitude that the Ship is in	12	18 N.

Admit a Ship at Sea the 29 day of *June*, *An.* 1695. and the Sun being upon the Meridian, I find by observation that the upper limb of the Sun is 6 deg. 42 min. to the Northward of my Zenith, I demand the Latitude that I am in.

Suns Declination North	22. deg.	26 min.
Suns Semidiameter add	00	16
Suns supream marg. dist. from Zenith	06	42
Distance of Suns center from Zenith	06	58
Latitude that the Ship is in	15	28

A Ship at Sea the 21 of *July*, *Anno* 1682. and I am in Longitude 165 deg. *West*, and the Sun being upon the Meridian, I find by observation that the supream margine of the Sun is 16 deg. 45 min to the Northward of my Zenith, I demand the Latitude that the Ship is in.

Declination North		18. deg.	15 min.	
Proportional minutes	subst.	00	06	
Suns Declination in the Merid given		18	09	
Suns supream marg. dist. from Zenith		16	45	
Suns Semidiameter	add	00	16	
Suns center distant from Zenith		17	01	
Latitude that the Ship is in		01	08	N.

Rules for observation in South Latitude.

Admit a Ship at Sea the 15 day of *July*, *An.* 1691. and I am in Longitude 150 deg. *East*, and the Sun being upon the Meridian, I find the Complement of his Meridian altitude by observation to be 48 deg. 28 min. *North*, I demand the latitude that the Ship is in.

Complement of Meridian altitude		48 deg.	28 min.	
Suns Semidiameter	add	00	16	
Suns center distant from Zenith		48	44	
Declination North	substract	19	47	
Latitude that the Ship is in		28	57	*S.*

Admit a Ship at Sea the 25 of *Octob.* *Anno* 1685, and in Longitude 120 deg. West, and the Complement of the Suns Meridian altitude by observation is 27 deg. 29 min. North, I demand the Latitude that the Ship is in.

Complement of Meridian altitude		27 deg.	29 min.	
Suns Semidiameter	add	00	16	
Suns center distant from Zenith		27	45	
Declination South	add	15	46	
Latitude that the Ship is in		43	31	*S.*

Admit a Ship at Sea the 25 of *December*, *Anno* 1694. and I find the Sun upon the South part of the Meridian, and I find by observation that the complement of the Suns Meridian altitude is 15 deg. 10 m. I demand the Latitude the Ship is in.

Com-

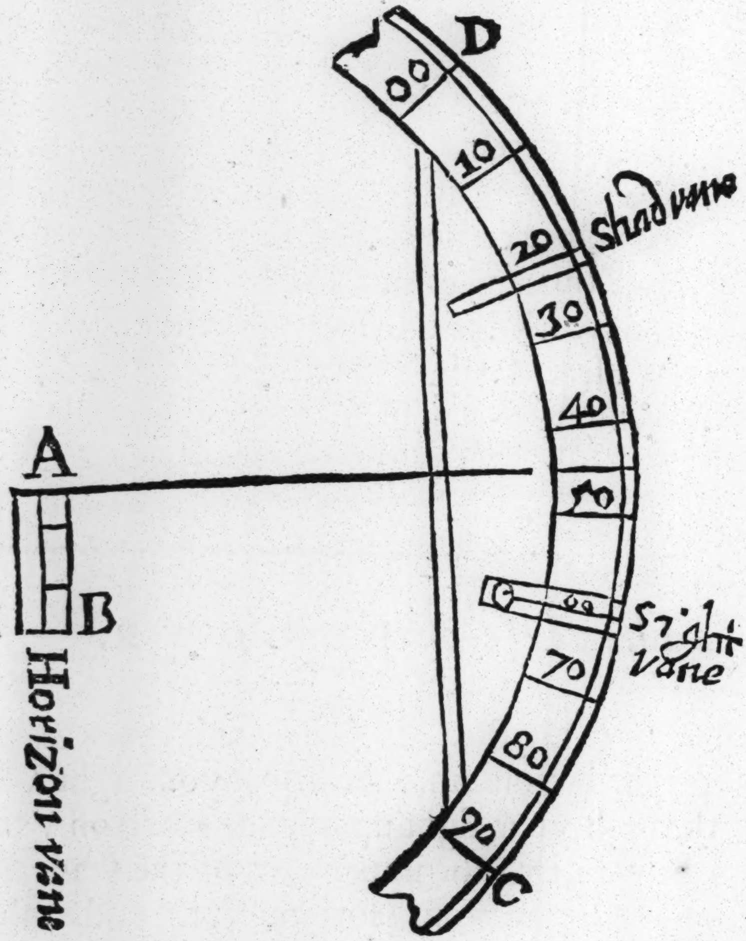
Complement of Meridian altitude		15 deg.	10 min.
Suns Semidiameter	add	00	16
Suns center from the Zenith		15	26
Declination South		22	45
Latitude that the Ship is in		07	19 S.

Thus much I thought neceſſary to add by way of explanation of the foregoing Tables, to ſhew a perfect way of Obſervation. I might, I confeſs, have been more copious herein, but not more plain; and that perſon who reads this, and cannot underſtand the uſe of the Tables, and how to take and work his Obſervation with more exactneſs than hath been formerly uſed, I ſay, I may very well rank ſuch a perſon amongſt the diſ-ingenious, as a man unfit to intermeddle with things of this nature.

The Uſe of the BOWE.

TAke the handle of the Bowe in your hand, *viz.* C, and hold your Bowe as upright as you can, then bring your ſight Vane to your eye, and look through your ſight upon your Horizon Vane, and you muſt hold your Bow ſo, that the upper part of the ſhade may lie upon the upper part of the ſlit on your Horizon Vane, and at the ſame time you muſt look for the Horizon, through the ſlit of your Horizon Vane: But if you cannot ſee the Horizon, but you do ſee all sky and no water, you muſt then draw your ſight Vane a little lower down towards C. But if on the contrary, you do ſee all water and no sky, then ſlide your ſight Vane a little higher up towards D, and then make obſervation again, aad then if the upper part of the ſhade doth lie upon the upper part of the ſlit, and at the ſame time you do ſee the Horizon through your ſight, and ſo through the ſlit of the Horizon Vane, then that is all that you have to do. Then you muſt wait and make obſervation as often as your judgment ſhall think fit, until ſuch time as the Sun be on the Meridian; and if the Sun be to the Weſtwards of the Meridian, then you will perceive the Sun to be fallen, and then you will not ſee the Horizon when you obſerve, for the water will hide it from you, and then you have done obſerving for that time. Then

Then look what degrees and minutes do ſtand againſt your ſight at your ſight Vane, which note, and look likewiſe what degrees do



ſtand by the upper part of the ſhade Vane; which ſubſtract from the former degrees noted by the ſight Vane, and the remainer is the Suns Meridian altitude, or the diſtance of the upper part of the Sun from the Horizon, from which if you ſubſtract 16 minutes, which is the Suns Semidiameter, the remainer will be the diſtance of the Suns center from the Horizon, or the true Meridian altitude.

Now for to work your Obſervation, after you have the true Meridian altitude, you are to follow the ſame method that I have given you for the *Foreſtaff*.

The Use of the NOCTURNAL.

SEt the Tooth to the day of the Month, and hold it fast standing in that sort: Then lift up the Instrument, and hold it as upright as you can, only bow the uppermost part thereof so much towards you, until you may see the North Star through the hole in the center of the Nocturnal. Now when yon see the North Star through the hole, then wind the Rule about, until by the cyphered edge of the Rule you may see the first of the Guards on the *Little Bear*; now if at the same time you see the North Star through the hole, and the first of the Guards on the *Little Bear*, by the edge of the Rule, then that is all that you have to do at that time. Then look by the edge of the Rule on the Hour Circle, and you will see the true hour of the Night. And see what point of the Compass the edge of the Rule standeth by, and that point sheweth you the bearing of the Guard Star from the North Star.

Example.

Admit the 10 *day of* February *I observe at* 7 *a clock in the evening, I demand the Bearing of the Guard Star from the North Star.*

If you look on the backside of the Nocturnal, you will find the edge of the Rule to stand against the North-east point, which is the point of Bearing desired.

¶ You are to take notice that you must always hold the Fore-side of the Nocturnal next your face.

Admit I observe the height of the North Star to be 42 *deg.* 10 *min. and I find by the Nocturnal at the same time that it is a N E by N Guard, I demand the height of the Pole.*

The Table that is in the 87 page of the *Seamans Kalender* sheweth, that when it is a N E by N Guard, the North Star is 1 deg. 3 min. above the Pole; therefore I substract this 1 d. 3 m. from 42 d. 10 m. and the remainer is 41 d.7 m. which is the height of the Pole desired.

Admit I observe the height of the North Star to be 45 *deg.* 22 *m. and I find by the Nocturnal at the same time, that it is a S S E Guard, I demand the height of the Pole.*

By

By the Table abovesaid, I find that with a *S S E* Guard the North Star is 2 deg. 29 min. under the Pole, therefore I add this 2 deg. 29 min. to 45 deg. 22 min. and the sum is 47 deg. 51 min. which is the heighth of the Pole desired.

The Use of GUNTERS LINES *in* NAVIGATION.

A Ship being in the Latitude of 43 deg. 30 min. North, she sails *S W by S.* 104 leagues, I demand the Latitude that she is in, and the departure from the Meridian.

Set one foot of your Compasses in 8 points and extend the other to 3 points, then set one foot in 104 in the line of numbers, and extend the other backward, and it will fall in 58 leagues, which is the departure from the Meridian: Then set one foot in 8 points, and extend the other to 5 points; then set one foot in 104 number, and extend the other backward, and it will fall in 86 Leagues, which is the difference of Latitude.

86 (4 d. 18 m	43 d.	30 m.	*Latitude departed*
20	4	18	
	39	12	*Latitude the Ship is in:*

A Ship being in the Latitude of 50 *deg.* 20 *m. North, sails* NNW 87 *leagues, I demand the Latitude that she is in, and the departure from the Meridian.*

Set one foot in 8 p. and extend the other to 2 p. then set one foot in 87 N. and extend the other backward, and it will fall in 33 leagues, which is the departure from the Meridian. Then set one foot in 8 p. and extend the other to 6 p. then set one foot in 87 N. and extend the other backward, and it will fall in 80 leagues, which is the difference of Latitude

80 (4 d. 00 m.	50 d.	20 m.	*Latitude departed*
20	4	00	
	54	20	*Latitude the Ship is in.*

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A Ship being in the Latitude of 51 *deg.* 15 *m. North, ſhe ſails* SEbS, *until ſhe be in the Latitude of* 46 *deg.* 45 *min. I demand the diſtance run, and the departure from the Meridian.*

Set one foot in 8 p. and extend the other to 5 p. then ſet one foot in 90 n. and extend the other forwards, and it will fall in 109 leagues, which is the diſtance run.

Set one foot in 5 p. and extend the other to 3 p. then ſet one foot in 90 n. and extend the other backward, and it will fall in 60 leagues, which is the departure from the Meridian.

A Ship being in the Latitude of 48 *deg.* 00 *m. North, ſhe ſails between the South and the Eaſt until ſhe be in the latitude of* 42 *deg.* 30 *m. and till her diſtance run be* 134 *leagues: I demand the Courſe that ſhe hath ſailed, and the departure from the Meridian?*

Latitude departed	48 deg.	00 min.
Latitude ſhe is in	42	30
Difference of Latitude	05	30
Leagues	110	

Set one foot in 134 N. and extend the other to 110 N. then ſet one foot in 90 ſines, and extend the other backward, and it will fall in 55 deg. 00 min. ſines, which is the complement of the courſe; therefore the courſe is 35 deg. 00 min. from the South-eaſt-wards.

Set one foot in 90 d. ſine, and extend the other to 35 d. ſine, then ſet one foot in 134 N. and extend the other backward, and it will fall in 77 N. which is the departure from the Meridian.

A Travis.

A Ship being in the latitude of 40 *d.* 00 *m. North, ſhe ſails* S E b S 68 *miles, and then ſails* S W b S 55 *miles, and then ſails* W N W 75 *miles; I demand the courſe and diſtance ſailed from the firſt place of departure?*

Set one foot in 8 p. and extend the other to 3 p. then ſet one foot in 68 n. and extend the other backward, and it will fall in 38 N. which in is the Eaſting in the firſt courſe.

Set one foot in 8 p. and extend the other to 5 p. then ſet one foot in 68 n and extend the other backward, and it will fall in 56 N. which is the Southing of the firſt courſe.

Next Set foot one in 8 p. and extend the other to 5 p. then ſet one foot in 55 N. and extend the other backward, and it will fall in 45 N. which is the Weſting in the ſecond courſe. Set one foot in 8 p. and

extend the other to 3 p. then ſet one foot in 55 n. and extend the other backward, and it will fall in 30 n. which is the Southing in the ſecond courſe. Set one foot in 8 p. and extend the other to 6 p. then ſet one foot in 75 n. and extend the other backward, and it will fall in 69 n. which is the Weſting in the third courſe. Then ſet one foot in 8 p. and extend the other to 2 p. then ſet one foot in 75 n. and extend the other backward, and it will fall in $28\frac{1}{2}$ n. which is the Northing in the third courſe.

North	*South*	*East*	*West*
$28\frac{1}{2}$.	56	38	45
	50.	114	69
	86	76 *dept.*	114
	$28\frac{1}{2}$.		
	$57\frac{1}{2}$ *difference of Latitude.*		

Set one foot in 76 n. and extend the other to $57\frac{1}{2}$ n; then ſet one foot in 45 d. tan. and extend the other backward, and it will fall in 53 deg. 00 min. tan. which is the courſe from the Southweſtward, *viz.* S W 8 deg. Weſt. Set one foot in 90 ſine, and extend the other to 53 d. ſine, then ſet one foot in 76 n. and extend the other forward, and it will fall in 96 n. which is the diſtance run from the firſt place of departure.

x

57(2 d. 52 m.	40 d.	00 m.	*Latitude departed*
20	2	52	*diff. of Latit. Sub.*
	37	08	*Latit. the Ship is in.*

A Ship being in the Latitude of 50 deg. 10 m. North, and in Longitude 5 d. 24 m. Weſt, ſhe ſails firſt S S E *72 miles, and then ſails* W S W *45 miles, and then ſails* E b N *67 miles, and then ſails* N N E *85 miles, and then ſails* W S W *40 miles, now I demand the courſe and diſtance ſailed from the firſt place of departure? likewiſe the latitude and longitude that the Ship is in.*

1 Courſe

1 Course	8 p	2 p	72 n	27½ n	East
	8 p	6 p	72 n	66 n	South
2 Course	8 p	6 p	45 n	41 n	West
	8 p	2 p	45 n	17 n	South
3 Course	8 p	7 p	67 n	65½ n	East
	8 p	1 p	67 n	13 n	North
4 Course	8 p	2 p	85 n	32 n	East
	8 p	6 p	85 n	78 n	North
5 Course	8 p	6 p	40 n	36½ n	West
	8 p	2 p	40 n	15 n	South

North	*South*	*East*	*West*
13	66	27½	41
78	17	65½	36½
	15	32	
91			77½
	98	125	
Northing	*Southing*	*Easting*	*Westing*

Southing	98	*Easting*	125
Northing	91	*Westing*	77½
Differ. of Latit.	07	*Departure*	47½

Set one foot in 47½ n. and extend the other to 7 n. then set one foot in 45 d. tan. extend the other backward, and it will fall in 81 d. 36. m. tan. which is the course from the South Eastwards, *viz.* E *by* S ¼ E. Set one foot in 90 deg. sine, and extend the other to 81 deg. 36. m. sine, then set one foot in 47½ n. and extend the other forward, and it will fall in 48 n. which is the distance run from the first place of departure.

The Latitude departed	50 deg.	10 m.
Difference of Latitude	00	07
The Latitud. the Ship is in	50	03
	100	13
The middle Latitude	50	6

Set one foot in 90 deg. sine, and extend the other to 39 deg. 54 m. sine, then set one foot in $47\frac{1}{2}$ n. and extend the other forward, and it will fall in 74 n. which is the difference of longitude in miles.

Longitude departed	5 deg.	24 m.	
Difference of Longitude	1	14	
The Longitude the Ship is in	4	10	West.

Note, If you be in West Longitude, and sail to the Eastward, and must substract your difference of Longitude from your Longitude departed, and the remainer is the Longitude that the Ship is in: But if you sail to the Westward, you must add your difference of Longitude to the Longitude departed, and the Sum is the Longitude that you are in: But if you be in the East Longitude, then sailing to the Eastward your Longitude increaseth, and sailing to the Westward your Longitude decreaseth.

A Ship being in the Latitude of 41 deg. 30 m. North, and in Longitude 10 deg. 20 min. East, she first sails S E *by* S *52 miles, and then sails* SS W *63 miles, and then sails* E *by* N *47 miles, and then sails* N *by* E $\frac{1}{2}$ E *35 miles, and then sails* N N W $\frac{1}{4}$ W *67 miles, and then sails* W N W *73 miles. Now I demand the course and distance sailed from the first place of Departure, likewise the Latitude and Longitude that the Ship is in.*

	M.	P.	P.	N.	N.		P.	P.	N.	N.	
S E by S	52	8	3	52	$28\frac{3}{4}$	E	8	5	52	43	S
S S W	63	8	2	63	24	W	8	6	63	58	S
E by N	47	8	7	47	46	E	8	1	47	09	N
N E b E $\frac{1}{2}$ E	35	8	$5\frac{1}{2}$	35	31	E	8	$2\frac{1}{2}$	35	$16\frac{1}{2}$	N
N N W $\frac{1}{4}$ W	67	8	$2\frac{1}{4}$	67	$28\frac{1}{2}$	W	8	$5\frac{3}{4}$	67	60	N
W N W	73	8	6	73	67	W	8	2	73	$27\frac{1}{2}$	N

North

North	*South*	*East*	*West*
9	43	28¾	24
16½	51	46	28½
60		31	67
27½	101 South		
		105¾ Easting	119½ Westing
113 Northing			105¾
101			
			13¾
12 *diff. Latitude*			*depart. Merid.*

Set one foot in 12 n. and extend the other to 13¾ n. then set one foot in 45 deg. tan. and extend the other backward, and it will fall in 48 deg. 50 min. tan. which is the course from the North Westward, *viz.* N W 3 deg. 50 min. West. Set one foot in 90 d. sine, and extend the other to 48 deg. 50 min. sine, then set one foot in 13¾ n. and extend the other forward, and it will fall in 18¼, which is the distance run from the first place of the departure.

Latitude departed	41 deg.	30 m.
Difference of Latitude	00	12
Latitude the Ship is in	41	42
	18	12
Middle Latitude	41	36

Set one foot in 90 deg. sine, and extend the other to 48 d. 24 m. sine, then set one foot in 13¾ n. and extend the other forward, and it will fall in 18¼ n. which is the difference of Longitude in miles.

Longitude departed	10 deg.	20 m.
Difference of Longitude subst.	0	18
Longitude the Ship is in	10	02

The

The Use of GUNTERS LINES *in measuring* OF BOARD *and* TIMBER.

Admit a Board to be 10 inches broad, and 20 foot long, I demand the Content.

Set one foot in 12, and extend the other to 10, then set one foot in 20, and extend the other backward, and it will fall in 16 foot and a half, which is the content of the Board required.

Admit a Board to be 15 inches broad, and 27 foot long, I demand the content.

Set one foot in 12, and extend the other to 15, then set one foot in 27 and extend the other forward, and it will fall in 34 foot, which is the content required.

Admit a Board to be $7\frac{1}{2}$ inches broad, and 29 foot long, I demand the content.

Set one foot in 12, and extend the other to $7\frac{1}{2}$, then set one foot in 29, and extend the other backward, and it will fall in 18 foot; which is the content required.

Admit a Board to be 27 inches broad, and 9 foot and a half long, I demand the content.

Set one foot in 12, and extend the other to 27, then set one foot in $9\frac{1}{2}$, and extend the other forward, and it will fall in $21\frac{1}{2}$ foot; which is the content required.

Admit a piece of Timber to be 8 inches square, and 20 foot long, I desire to know how many square foot there is contained in this piece of Timber.

Set one foot in 12, and extend the other to 8, then set one foot in 20, and extend that distance twice backward, and it will fall in 8 foot 3 quarters, which is the content required.

Admit a piece of Timber to be $9\frac{1}{2}$ inches square, I demand the content.

Set

Set one foot in 12, and extend the other to $9\frac{1}{2}$, then ſet one foot in 27, and extend that diſtance twice backward, and it will fall in 17 foot; which is the content required.

Admit a piece of Timber to be 18 inches ſquare, and 9 foot long, I demand the content.

Set one foot in 12, and extend the other to 18; then ſet one foot in 9, and extend that diſtance twice forward, and it will fall into $20\frac{1}{2}$ foot; which is the content required.

Admit a piece of Timber to be 22 inches ſquare, and 35 foot long, I demand the content.

Set one foot in 12, and extend the other to 22; then ſet one foot in 35, and extend that diſtance twice forward, and it will fall in 118 foot; which is the content required.

The Uſe of the SECTOR *in Navigation.*

A Ship being in the Latitude of 42 deg. 20 min. North, ſhe ſails *NEbN* 104 leagues, I demand the Latitude that ſhe is in, and the departure from the Meridian.

Firſt take the half of 104, which is 52, from the Line of Lines, then ſet one foot in 90 deg. ſines, and open the Sector till the other foot toucheth 90 deg. ſines on the other part of the Sector, and there let the Sector ſtand; then ſet one foot in 33 deg. 45 min. ſines, and extend the other to 33 deg. 45 m. ſines, and meaſure that diſtance on the line of lines, and it will be 29, the double of it is 58 leagues, which is the departure from the Meridian. Set one foot in 56 deg 15 min. ſine, and extend the other to 56 deg. 15 min. ſine, and meaſure that diſtance on the line of lines, and it will be $43\frac{1}{2}$, the double of it is 87 leagues, which is the difference of Latitude.

87(4 d. 21 m.		42 d.	20 m.	*Latitude departed.*
20		4	21	*Difference* add
		46	41	*Latit. the Ship is in.*

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